DOCUMENT RESUME

ED 191 712 SE 031 937

AUTHOR Klassen, Daniel L.: And Others
TITLE A Study of Computer Use and Literacy in Science Education. Final Report, 1978 - 1980.
INSTITUTION Minnesota Educational Computing Consortium, St. Paul.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE 80
GRANT NSF-SED-77-18658
NOTE 208p.: Not available in hard copy due to marginal legibility of original document. Appendices A, C, and G removed due to copyright restrictions. Appendix F missing from document prior to its being shipped to EDRS for filming.

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Computer Assisted Instruction: *Computer Oriented Programs: Computer Programs: Computers: *Computer Science Education: *Science Education: Secondary Education: Secondary School Science

ABSTRACT

This research project was designed to provide information which will be of assistance to science educators responsible for and interested in the development, implementation and evaluation of educational programs and courses designed to foster computer literacy. A questionnaire concerning computer use in the classroom was answered by 3,576 science teachers. The data from the questionnaire demonstrate that teachers strongly support minimal understanding of computers and their societal role for every secondary school student and that they generally feel positive about the value of computers in education. Responses of the 929 students who had been exposed to instructional computing activities demonstrated significant gains in both affective and cognitive dimensions of computer literacy. (Author/DS)

# A STUDY OF COMPUTER USE AND LITERACY IN SCIENCE EDUCATION

Final Report

1978 - 1980

Minnesota Educational Computing Consortium
2520 Broadway Drive
St. Paul, Minnesota 55113

1980

Supported by Grant No. SED 77-18658 from the National Science Foundation to the Special Projects Division of the Minnesota Educational Computing Consortium.

Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the National Science Foundation.

## ACKNOWLEDGMENTS

This project has involved the active participation and support of nearly 5,000 students and 4,000 teachers, as well as many school administrators, state education agency personnel, computer educators from throughout the country and consultants. We would like to express our deepest thanks to all of these individuals. Without them it would have been impossible to successfully complete a project of this magnitude and duration. We would especially like to thank the students and teachers who participated in the field study and the experiment.

In addition to the Minnesota students and teachers, we want to thank the following individuals who helped us in important and substantial ways: Mr. David Tinsley of Birmingham, England; Dr. Lud Braun of the State University of New York at Stony Brook; Dr. Judy Edwards of the Northwest Regional Educational Laboratory; Dr. Tom Liao of the State University of New York at Stony Brook; Dr. Phil Reese of the State University of New York at Stony Brook; Dr. Mike Niell of the University of Oregon; Dr. Mark Davison of the University of Minnesota; Dr. Ed Andersen of Southwest High School in Minneapolis; and Beverly Hunter of the Human Resources Research Organization in Alexandria, Virginia. We also wish to thank those individuals that reviewed our computer literacy objectives and the Minnesota Educational Computing Consortium's instructional coordinators for their help.

Karl Krohn, Barb Davis, Mark Sulzbach, Linda Harris, Scott Wilcoxson and Dr. Richard Sandman assisted the project team. We would like to thank them for their hard work and dedication to the project.

Dr. Andrew Molnar of the National Science Foundation served as our project officer. He provided support and advice along with a keen interest in the topic. We thank him for this. We also wish to thank the National Science Foundation for its financial support of this project.

Finally, we would like to thank the clerical staff that did all of the important organizational, typing, filing and other necessary tasks. Thanks to Robin Jokela, Pat Ferrazzo, Marion Collier and Harriet Anderson. A special tribute goes to Harriet Anderson who was with us for the majority of this effort and who typed this report. Without her this project would have been much less pleasant.

The Project Team

Daniel L. Klassen, Project Director
Ronald E. Anderson, Project Co-Director
Thomas P. Hansen, Research Associate
David C. Johnson, Faculty Associate

CONTENTS

APPENDICES

Appendix A -- "Instructional Computing: Acceptance and Rejection by Secondary School Teachers"

Appendix B -- "The Computer Mystique"

Appendix C -- "Computer Literacy - What Is It?"

Appendix D -- "A Survey About Education and Computing"

Appendix E -- Computer Literacy Questionnaire

Appendix F -- "The Minnesota Computer Literacy Tests: A Technical Report"

Appendix G -- "Computer Literacy Courses"

Appendix H -- Course/Unit Activity Log and Participant Questionnaire

CHAPTER 1

# A SURVEY OF COMPUTER USE AND LITERACY IN SCIENCE EDUCATION

# Chapter 1

## A STUDY OF COMPUTER USE AND LITERACY IN SCIENCE EDUCATION

### Introduction

Computers are rapidly becoming a dominant technological force in American society. It is, in fact, very unlikely that the average American citizen will be able to remain untouched by the presence and influence of this pervasive technology in the years to come.

This trend has not gone unnoticed within the educational establishment and the need for an appropriate educational response has been sounded with increasing frequency. Some go so far as to suggest that "ignorance of computers will render people functionally illiterate as does ignorance of reading, writing and arithmetic" (Michael, 1968) and that educational remedies are imperative.

While universal agreement on the need to educate all students about computers and computer uses has not been reached, a growing number of educators believe that all students should be provided with educational opportunities which will allow them to become computer literate.

As the belief in the need to educate future citizens in the operation, use and impact of computers gains support in educational circles and within the public-at-large, it is becoming increasingly clear that science educators in our nation's schools will be called upon to provide guidance for the development of computer oriented educational programs and courses, and to provide the necessary learning opportunities and resources. The teaching of science in American schools has traditionally been carried on for three basic reasons: (1) to prepare scholars in the various disciplines of science, (2) to provide the background and training required of individuals entering technological occupations and professions, and (3) to provide a background in science and technology as a part of the general education of the individual for effective citizenship. Education for citizenship in a computer society is an important motive behind the current growth in the use and study of computers in American schools and as such, places computer literacy clearly within the framework of science education.

This research project was undertaken in order to provide information which will be of assistance to science educators responsible for and interested in the development, implementation and evaluation of educational programs and courses designed to foster computer literacy. Since the development of instructional programs designed to promote computer literacy at the pre-college level is in its infancy, we felt it important to collect baseline data regarding student knowledge and understanding of computers which could be used to help shape effective educational programs. Just as no medical doctor would prescribe a treatment without first making a diagnosis, we believe that science educators need to know what students know and feel about computers in order to prepare and implement effective educational programs.

In addition to providing baseline data regarding computer literacy levels, the project was designed to determine the relative impact of the various computing or computer-related activities in schools on the development of computer knowledge and understanding. Because educational programs in this area have only recently been initiated, little is known about the types of instructional activities used to promote computer literacy, and perhaps more importantly, about the impact of the various computer-related experiences on students' knowledge, attitudes and skills. We were especially interested in understanding how time spent using the computer within an educational setting affects student attitudes and knowledge. If, as some suggest, use of the computer as an instructional tool (computer assisted instruction) in science education can produce, as a by-product or side-effect, students who are computer literate, then science educators can take advantage of this situation in designing their educational programs and learning activities.

Our effort to produce this information involved a number of different data collection strategies. In order to identify the typical computing or computer related activities in schools, we conducted a survey of all secondary school (grades 7-12) science, mathematics, computer science, data processing, and business education teachers in Minnesota. This survey produced responses from over 3,500 teachers and provided a great deal of useful information concerning the nature and scope of computer use in science education, and about the commonly used methods and activities designed to promote computer understanding and awareness. The results of this survey are discussed in Chapter 3 and in a recent article published in the journal Sociology of Work and Occupations. (See Appendix A)

Using the information collected via this survey of teachers as a guide, we selected approximately 60 teachers who were planning to include computers in their classes and asked them, along with their students, to participate in an extensive effort to determine computer literacy levels among students. This research involved over 1000 students in an assessment effort which began prior to computer use or instruction about computers and ended with post-testing at the conclusion of their involvement with computers. The results of this rigorous assessment program, along with information provided by the participating teachers, provide the basis for the analysis and interpretation presented in Chapter 4 of this report.

In addition to the teacher survey and the testing of students within the framework of their regular classroom environment, we conducted a controlled educational experiment to determine student attitudes and knowledge of computers within the context of their direct participation in a science-oriented, computer assisted instruction experience. Over 350 students participated in this effort, which involved each student using a computer-based learning unit on water pollution and a related testing and data collection effort in a six-month follow-up study. The results of this research are described in Chapter 5 and in a paper entitled "The Computer Mystique." (See Appendix B)

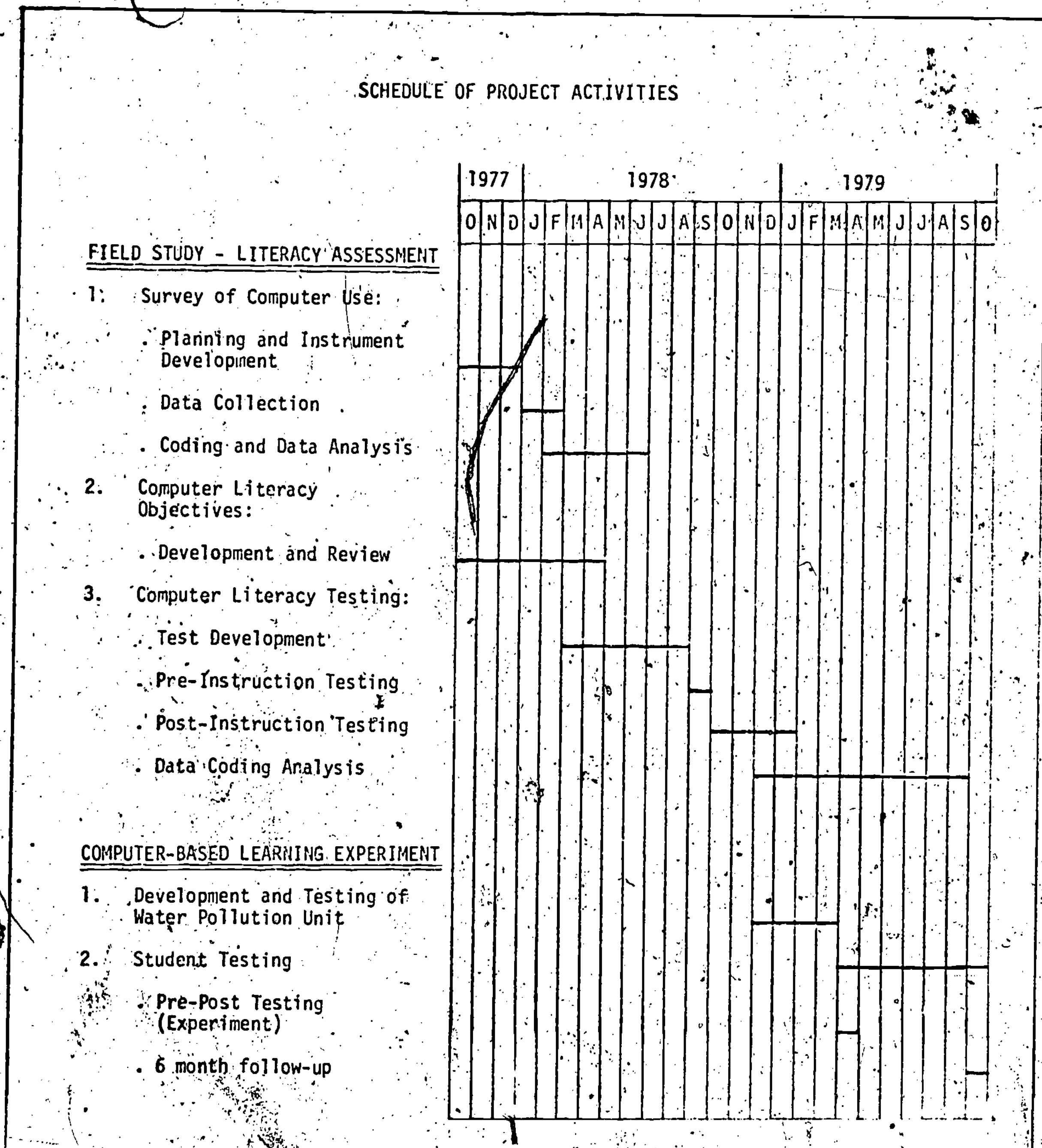
Schedule of Project Activities

Figure 1 shows the schedule of major project events. The project involved two major research efforts -- the field study and the computer-based learning experiment.

The field study consisted of three major activities:

1. A survey of all 6837 mathematics, science, business education, computer science, and data processing secondary school teachers in Minnesota's schools (grades 7-12). The primary purposes of this survey were: (1) to identify and determine the nature and scope of any computing activity and (2) to identify teachers whose classes could serve to represent various types of computing and computer activity.
2. The development of computer literacy objectives covering the following cognitive areas: computer hardware, software and data processing, programming and algorithms, applications, social impact, as well as attitude and value orientations. These objectives provided a framework for the organization and development of a test of computer literacy.

Figure 1


SCHEDULE OF PROJECT ACTIVITIES
1977
1978
1979
O N D J F M A M J J A S O N D J F M A M J J A S O
FIELD STUDY - LITERACY ASSESSMENT
1. Survey of Computer Use:
. Planning and Instrument Development
. Data Collection
. Coding and Data Analysis
2. Computer Literacy Objectives:
. Development and Review
3. Computer Literacy Testing:
. Test Development
. Pre-Instruction Testing
. Post-Instruction Testing
. Data Coding Analysis
COMPUTER-BASED LEARNING EXPERIMENT
1. Development and Testing of Water Pollution Unit
2. Student Testing
. Pre-Post Testing (Experiment)
. 6 month follow-up

3. The development, validation and administration of a computer literacy test called the Computer Literacy Questionnaire. The test, which contained cognitive and affective items was used for pre- and post-instruction assessment with approximately 1100 secondary school students in 60 different classrooms.

The experiment in computer learning consisted of two major activities:

1. The development and testing of a completely self-contained, computer-delivered science lesson called APOLUT. This unit, dealing with the process of water pollution, was used to provide different types of computer learning experiences during the experiment.
2. Completion of a questionnaire by students before and after their use of the 20-30 minute computer based unit on water pollution and then again six-months following their experience with the computer based unit.

This study was conducted entirely within Minnesota. While it would have been desirable to conduct a study such as this one on a national basis, it would have been financially and operationally difficult. Minnesota was selected for a number of reasons. First, the project team was familiar with computer ~~use~~ in the state and had developed the contacts and rapport required to conduct a school based study of this nature. Second, Minnesota schools have been active in the use of computers for many years and contained a representative mix of different types of computer users and computer uses. The level of computer use was also high enough to ensure that all types of computer use and computer literacy programs would be represented. Finally, Minnesota is quite average when viewed in terms of many educational, geographical and socio-economic factors. (See Table 1) This is important when it comes to attempting to generalize from the results of the research.

Table 1

COMPARISON VARIABLES
(MINNESOTA VS. UNITED STATES VS. OTHER STATES)

| | | Minn. | U.S. | MN-Relative Rank |
|---|---|---|---|---|
| 1) | Per Capita Income, 1975 | $4,825 | $4,838 | 20.0 |
| 2) | Percent High School Grad, 1976 | 72.0 | 67.0 | 16.0 |
| 3) | Median School Years Completed | 12.5 | 12.5 | 22.0 |
| 4) | Percent Urban, 1976 | 64.4 | 73.0 | 30.0 |
| 5) | Percent Rural, 1976 | 35.7 | 27.1 | 30.0 |
| 6) | Percent Black, 1975 | 1.0 | 11.5 | 37.0 |

Source: U.S. Bureau of the Census, Statistical Abstracts of the U.S.: 1978, 99th edition, Washington, D.C., 1978.

This report contains a summary of the major project activities; a discussion of the research methods, including a description of the data collection instruments; a discussion of the results; and a brief summary of the major findings and conclusions.

Chapter 2 of the report presents background information on the concept of computer literacy. It also presents the list of computer literacy objectives which were developed and used by the research team to structure the entire research effort. These objectives are important because they provide the focus for our data collection effort as well as the subsequent analysis and conclusions.

Chapter 3 and the article contained in Appendix A report on the teacher survey. We have chosen to report on this survey in a separate chapter because of the important information it provided. This survey was not the major focus of this research project and was done only as a preliminary step to the collection of data directly from students.

Chapter 4 focuses on what students know and believe about computers before and after instruction related to computers and/or computer use and on the relative impact of the various computing or computer related activities in schools on the development of computer literacy.

Chapter 5 contains a discussion of the experiment in computer-learning. The results of this experiment will help to clarify the impact of computer assisted instruction in science education and provide guidance to designers and users of computer based learning materials.

Chapter 6 summarizes the major findings which emerged from the conduct of the research as well as discussing some of the implications of what we found.

The report also contains a number of appendices. Some contain the data collection instruments along with data generated by their use. Others contain reports of this research which have already been published in professional journals or released as technical reports.

## REFERENCES

Michael, D. N. THE UNPREPARED SOCIETY, New York Basic Books, Inc. 1968.

# CHAPTER 2

## COMPUTER LITERACY: TOWARD AN EMPIRICAL DEFINITION

## Chapter 2

# COMPUTER LITERACY: TOWARD AN EMPIRICAL DEFINITION

While the term computer literacy is rapidly becoming a common part of the language of science education, it remains, unfortunately, ill-defined and vague. At the conceptual level, computer literacy provides a convenient way of referring to a diffuse collection of knowledge, beliefs, attitudes, values and skills; however, the specific knowledge, skills and attitudes necessary to qualify an individual as having achieved computer literacy remains uncertain.

Computer literacy is one of many terms used to denote some basic understanding of computers. Other terms include computer appreciation, computer awareness, computer competency and computeracy. Each of these terms, according to its proponents, stresses different aspects of computer-related knowledge, attitudes and skills; but like computer literacy, also lack a clear, operational definition.

Literacy is commonly defined as the quality or state of being literate, especially the ability to read and write. Computer literacy, building upon this general definition, refers to the quality or state of being literate vis-a-vis computers and by analogy implies an ability to communicate with computers. Computer literacy as we use the term consists of whatever general knowledge, skills, or attitudes are necessary to "deal with" computers and computer applications. As such it is a relative, non-specific, evolving concept.

Despite the lack of a specific definition, we believe that the concept of computer literacy is useful and should be operationalized to allow for the assessment of literacy levels in various populations. Computer literacy is now a widely used term which has come to refer to the level of understanding a person's needs to function effectively in a computerized society. This general definition can be further refined and operationalized for research and educational purposes.

Since our research was designed to measure computer literacy levels among secondary school students and to help us better understand how computer-related instruction affects knowledge and attitudes, we were faced with the necessity of developing an operational definition of the concept which could be used as the foundation for a measurement instrument. Since concepts, in order to be useful as explanatory tools, must be measured in concrete and operational ways, we spent considerable time and effort constructing an operational definition of computer literacy. We have defined the concept of learning in the form of specific learning objectives and not as a typical dictionary defintion. We believe that these objectives represent an important step toward the refinement of computer literacy as a useful concept in science education.

We must, at the same time, remind the reader that computer literacy, since it is a condition of human knowledge levels, attitudes and skills, depends on the specific role, responsibilities, or needs of the individual. If we are to require our schools to produce computer literates, as many now propose, we must provide working definitions of the term which can be used to help structure instructional activities and to provide the basis for student and program assessment. After all, we need to know where we are going so we can determine whether or not we have arrived.

What follows is a brief discussion of the emergence of computer literacy as an educational goal, a discussion of several common definitions, and a listing of the learning objectives used as the foundation for this research.

## Computers and Society

During the past decade, computer technology has come to play a very important, often pivotal, role in American scientific, business, industrial and governmental institutions. Efforts to improve productivity, increase efficiency and service, and to cope with the "information explosion" have spawned thousands of uses for computers. Our nation, it has been observed, has been transformed from an industrial society into an information society that relies heavily on computers and related information systems (Bell, 1973). According to a recent government report, the largest single class of employees in the United States today have jobs dealing, in the broadest sense, with information processing and communications, and it is well known that computer technology has influenced these areas extensively (Marc Uri Porat, 1977). In addition to the many known uses of computers, it is estimated that there are thousands of applications of the computer still awaiting discovery. As a recent TIME article put it, "amazing feats of memory and execution become possible in everything from automobile engines to universities and hospitals, from farms to banks and corporate offices, from outer space to a baby's nursery" (TIME, 1978). To ask what these applications are would be like asking what are the applications of electricity. There is little doubt, it seems, that life in the U.S. and in the rest of the industrial world, and eventually all over the planet, will be incalculably changed by computer technology.

## Need for Computer Literacy

The widespread use of computers and our growing reliance on computer supported applications and technologies have spawned a growing concern about the level of public understanding of computers and their potential consequences.

In an information society such as ours, widespread understanding of computer technology and the consequences of computer use and misuse is necessary, even required, for public policy-making (Engle, et. al., 1978). From the systemic perspective, a lack of understanding and acceptance of computers can seriously impede the use of computer technology in solving important problems. Many observers of the role of computer technology in society believe that if the gap between current technological capacity and the ordinary person's understanding of the technology is allowed to grow too wide, the social and political, as well as scientific ramifications, are likely to be very serious (Press, 1974). Special concern about computers and information systems seems justified because of their unique and pervasive features: capacity for information storage and manipulation, close association with large bureaucratic institutions, integration into the practice of science, and the potential for delivery of services directly to individuals (Amara, 1974).

For the individual, an understanding of computer technology is important because it reduces bewilderment about computers and promotes a balanced view of the computer's role in society. Such understanding also enables people to use and influence the design of computer-based social services and to develop informed opinions regarding computer applications which have political, economic and social implications. Donald Michael in The Unprepared Society goes so far as to suggest that "ignorance of computers will render people as functionally illiterate as does ignorance of reading, writing and arithmetic," (Michael, 1968).

Educational Efforts Urged

The growing recognition of the importance of widespread public understanding of computers in an information/computer society has prompted concerned educators to urge that educational efforts be launched to eliminate, or at least reduce, computer illiteracy. The President's Science Advisory Committee and the Organization for Economic Cooperation and Development, in the late 1960's, were among the first to recognize the need to educate citizens. (Computers in Higher Education, Report to the President's Science Advisory Committee, Washington, D.C., 1967, and SERI - Report Extracts, International World of Computer Education, Volume I, #5, 1974) At about the same time, many educational and scientific societies also recognized this need. The International Federation of Information Processing Societies' Working Group in Secondary School Education, for instance, suggested that since it is important for all students to understand the nature and use of computers in modern society, teachers of all subjects should have a knowledge of computing. (Computer Education for Teachers in Secondary Schools - An Outline Guide of the International Federation of Information Processing Societies, Geneva, Switzerland, 1971) The Association of Computing Machinery's Elementary and Secondary Schools Subcommittee's Working Group on Computing Competencies for Teachers has recently issued a similar plea (Taylor, 1979). The Conference Board of Mathematical Sciences has also recommended, on several occasions, the development of a computer literacy curriculum for pre-college students (Recommendations Regarding Computers in High School Education, Conference Board of the Mathematic Sciences, Washington, D.C., 1972) and in 1978, the National Council of Supervisors of Mathematics issued a position paper which included computer literacy for all citizens in a list of ten basic skills and the National Council for the Social Studies, has shown a recent interest in the topic as well.

In what is perhaps the most complete analysis of the importance of computer literacy, Andrew Molnar concludes that there is:

> ... a national need to foster computer literacy. Further, if we are to meet this need, we must ensure that high school graduates have an understanding of the uses and applications of the computer in society and its effect upon their every-day lives. ... A nation concerned with its social needs and economic growth cannot be indifferent to the problems of industries, we must develop a computer-literate society (Molnar, 1978).

Definitions of Computer Literacy

If one accepts the argument that all students need to have sufficient computer knowledge and skill to function as contributing members of a modern technological society, then the question of what constitutes sufficient knowledge and skill becomes an important concern. An early effort to answer this question came from the Committee on Computer Education of the Conference Board of the Mathematical Sciences, Washington, D.C., 1972. The committee recommended the development of at least one secondary school course in computer literacy which would, at a minimum, deal with: a) the ways computers are used, b) the capabilities and limitations of computers, and c) the concept of algorithms and their application in flowcharting and programming.

Since 1972, the call for computer literacy for all students has been heard with increasing frequency. Definitions of computer literacy have become more prevalent in the literature as well. David Moursund offers a typical definition:

> Computer literacy refers to a knowledge of the non-technical and low-technical aspects of the capabilities and limitations of computers, and of the social, vocational, and educational implications of computers (Moursund, 1975).

In Great Britain, Lali Makkar prefers to refer to this level of computer knowledge necessary for all society as "computer awareness." He states that general education is not making students sufficiently "computer aware." He defines computer awareness as:

> ...the possession of sufficient knowledge to enable inferences, general and social, to be made on the basis of what is seen or heard about computers (Makar, 1973).

Others take a more skill oriented approach to the definition of computer literacy claiming that computer programming skills are essential to understanding how computers work and the role of computers in society. Minsky, for example, suggests that "Eventually programming itself will become more important even than mathematics in early education" (Minsky, 1970). Denenberg argues that programming is an important aspect of computer literacy because it teaches thinking and problem solving skills (Denenberg, 1977).

The emphasis on programming skills as a part of computer literacy is not universally appreciated. Weizenbaum decries the teaching of programming without substance or without the teaching of worthwhile applications (Weizenbaum, 1976). He takes an additional step and argues that students should not be taught about computers unless they are taught about the social impact and implications of these tools.

Our own approach to the definition of computer literacy has been to focus upon the identification and definition of substantive areas or dimensions of computer literacy rather than to construct a new definition. While definitions ~~are~~ useful, our approach is designed to be more helpful to the classroom teacher and the educational researcher.

## The Dimensions of Computer Literacy

There are ~~several~~ broadly defined dimensions which are common to most definitions of computer literacy. First, there is a hardware dimension. Knowing the meaning of basic terms, such as hardware and memory are considered to be a minimum level of awareness and some understanding of the major components of a computer sytem and their functions is often considered essential. Some awareness of the historical development of computer hardware is sometimes included here as well.

A second dimension is that of software and data processing, which often includes knowledge of how data is processed by computers and the fact that the computers are instructed by people who write instructions in a specific computer language. In addition, a realization that computers store both the instructions (program) and the data within the memory is often viewed as critical.

Third, computer literacy can be said to have a programming and algorithm dimension. This dimension may include the ability to follow, modify, correct, and develop algorithms expressed both as a set of English language instructions and in the form of a computer program.

A fourth dimension is that of the application of computers in society. Computers are used in every sector of the society: in work, in government, in people's homes, and in school. Knowledge of when and where computers are being used and what makes a computer application suitable or unsuitable is deemed important.

The fifth dimension is impact, which is different from the application of computers in that it deals with the effects or results of applying computers. Many issues are addressed in this dimension including privacy, computer crime, computer careers, the impact of computers on employment, etc. It is also felt that students need to develop a realization of both the positive and negative impacts of computers.

The sixth and last dimension is that of computer specific attitudes and values. The premise of this aspect of computer literacy is that an individual should possess realistic attitudes such as an absence of fear, anxiety, and intimidation. A negative view of computers could hinder the development of knowledge and skills; a positive view fosters learning and openness to computer use.

Computer Literacy Objectives

These six basic dimensions were used by our research team as a framework for the development of the specific instructional objectives shown in Figure 2. A more extensive discussion of the methodology used to identify these dimensions is given in Chapter 4 of this report and in the February, 1980, issue of The Mathematics Teacher in an article entitled "Computer Literacy - What is it?". (See Appendix C) After the six dimensions were established, an extensive list of topics for each dimension was constructed. These topics were then used as the basis for the construction of the learning objectives shown in Figure 2. The topics were chosen after a systematic review of curriculum materials, textbooks, test items, etc. These objectives were developed to help define computer literacy and as a basis for the development of tests and attitude scales to assess computer literacy among students. The objectives that are designated with an "*" are those that were selected for assessment in this research effort.

For each cognitive objective, the first digit after the letter refers to a cognitive level - 1 indicating a low level, generally a skill or knowledge of facts while 2 stands for a higher level of understanding requiring some analysis and/or synthesis. The final digit is merely a count of items within each level. While no priority is intended with the final digit, there has been an attempt to place the ideas in a logical sequence. The coding scheme for the affective area, V.1 - V.9, is merely for recording purposes and is not intended to suggest any priorities or hierarchy.

Figure 2

## COMPUTER LITERACY OBJECTIVES - COGNITIVE

Hardware (H)

*H.1.1 Identify the five major components of a computer: input equipment, memory unit, control unit, arithmetic unit, output equipment.

*H.1.2 Identify the basic operation of a computer system. Input of data or information - processing of data or information - output of data or information.

*H.1.3 Distinguish between hardware and software.

*H.1.4 Identify how a person can access a computer; e.g.,
1. via a keyboard terminal
   a. at site of computer
   b. at any distance via telephone lines
2. via punched or marked cards
3. via other magnetic media (tape, diskette)

*H.1.5 Recognize the rapid growth of computer hardware since the 1940's.

*H.2.1 Determine that the basic components function as an interconnected system under the control of a stored program developed by a person.

*H.2.2 Compare computer processing and storage capabilities to the human brain listing some general similarities and differences.

Software and Data Processing (S)

S.1.1 Identify the fact that we communicate with computers through a binary code.

S.1.2 Identify the need for data to be organized if it is to be useful.

S.1.3 Identify the fact that information is data which has been given meaning.

S.1.4 Identify the fact that data is a coded mechanism for communication.

S.1.5 Identify the fact that communication is the transmission of information via coded messages.

*S.1.6 Identify the fact that data processing involves the transformation of data by means of a set of pre-defined rules.

*S.1.7 Recognize that a computer needs instructions to operate.

*S.1.8 Recognize that a computer gets instructions from a program written in a programming language.

*S.1.9 Recognize that a computer is capable of storing a program and data.

*S.1.10 Recognize that computers process data by searching, sorting, deleting, updating, summarizing, moving, etc.

*S.2.1 Select an appropriate attribute for ordering of data for a particular task.

S.2.2 Design an elementary data structure for a given application (that is, provide order for the data).

S.2.3 Design an elementary coding system for a given application.

Programming and Algorithms (P)

NOTE: The student should be able to accomplish objectives 1.2-2.5 when the algorithm is expressed as a set of English language instructions and in the form of a computer program.

P.1 Recognize the definition of "algorithm."

*P.1.2 Follow and give the correct output for a simple algorithm.

*P.1.3 Given a simple algorithm explain what it accomplishes (i.e., interpret and generalize).

~~*P.2.1 Modify a simple algorithm to accomplish a new but related task.~~

P.2.2 Detect logic errors in an algorithm.

P.2.3 Correct errors in an improperly functioning algorithm.

P.2.4 Develop an algorithm for solving a specific problem.

P.2.5 Develop an algorithm which can be used to solve a set of similar problems.

Applications (A)

*A.1.1 Recognize specific uses of computers in some of the following fields:
a. medicine
b. law enforcement
c. education
d. engineering
e. business
f. transportation
g. military defense systems
h. weather prediction
i. recreation
j. government
k. the library
l. creative arts

A.1.2 Identify the fact that there are many programming languages suitable for a particular application for business or science.

*A.1.3 Recognize that the following activities are among the major types of applications of the computer:
a. information storage and retrieval
b. simulation and modelling
c. process control - decision-making
d. computation
e. data processing

*A.1.4 Recognize that computers are generally good at information processing tasks that benefit from:
a. speed
b. accuracy
c. repetitiveness

*A.1.5 Recognize that some limiting considerations for using computers are:
a. cost
b. software availability
c. storage capacity

*A.1.6 Recognize the basic features of a computerized information system.

*A.2.1 Determine how computers can assist the consumer.

*A.2.2 Determine how computers can assist in a decision-making process.

A.2.3 Assess the feasibility of potential applications.

A.2.4 Develop a new application.

Impact (I)

*I.1.1 Distinguish among the following careers:
a. keypuncher/keyoperator
b. computer operator
c. computer programmer
d. systems analyst
e. computer scientist

*I.1.2 Recognize that computers are used to commit a wide variety of serious crimes but especially stealing money and stealing information.

*I.1.3 Recognize that identification codes (numbers) and passwords are a primary means for restricting use of computer systems, of computer programs, and of data files.

| | |
|---|---|
| I.1.4 | Recognize that procedures for detecting computer-based crimes are not well developed. |
| *I.1.5 | Identify some advantages or disadvantages of a data base containing personal information on a large number of people (e.g., the list might include value for research and potential for privacy invasion.) |
| I.1.6 | Recognize several regulatory procedures; e.g., privilege to review one's own file and restrictions on use of universal personal identifiers, which help to insure the integrity of personal data files. |
| *I.1.7 | Recognize that most "privacy problems" are characteristic of large information files whether or not they are computerized. |
| *I.1.8 | Recognize that competerization both increases and decreases employment. |
| *I.1.9 | Recognize that computerization both personalizes and impersonalizes procedures in fields such as education. |
| *I.1.10 | Recognize that computerization can lead to both great independence and dependence upon one's tools. |
| *I.1.11 | Recognize that while computers do not have the mental capacity that humans do, through techniques such as artificial intelligence, computers have been able to modify their own instruction set and do many of the information processing tasks that humans do. |
| *I.1.12 | Recognize that alleged "computer mistakes" are usually mistakes made by people. |
| I.2.1 | Plan a strategy for tracing and correcting a computer related error such as a billing error. |
| I.2.2 | Explain how computers make public surveillance more feasible. |
| *I.2.3 | Recognize that even though a person does not go near a computer, he or she is affected indirectly because the society is different in many sectors as a consequence of computerization. |
| I.2.4 | Explain how computers can be used to impact the distribution and use of economic and political power. |

## COMPUTER LITERACY OBJECTIVES - AFFECTIVE

| Attitude, Values, and Motivation (V) | |
|---|---|
| *V.1 | Does not feel fear, anxiety, or intimidation from computer experiences. |
| *V.2 | Feels confident about his/her ability to use and control computers. |
| *V.3 | Values efficient information processing provided that it does not neglect accuracy, the protection of individual rights and social needs. |
| *V.4 | Values computerization of routine tasks so long as it frees people to engage in other activities and is not done as an end in itself. |
| *V.5 | Values increased communication and availability of information made possible through computer use provided that it does not violate personal rights to privacy and accuracy of personal data. |
| V.6 | Values economic benefits of computerization for a society. |
| V.7 | Enjoys and desires work or play with computers, especially computer assisted learning. |
| V.8 | Describes past experiences with computers with positive-affect words like fun, exciting, challenging, etc. |
| V.9 | Given an opportunity, spends some free time using a computer. |

## Summary

These objectives represent an operational definition of computer literacy. They are "informational" objectives and not intended to define minimum competencies for secondary school students.

Our society's growing reliance on computers and computer applications demands that the public come to understand this phenomenon. Our schools are left with the responsibility to develop curricula in computer literacy. For instructional purposes this is generally understood to refer to the level of knowledge and understanding a person needs to function effectively in a computerized society. While we cannot previsely define computer literacy due to its situational nature, it is possible to define major components or dimensions of computer literacy. By developing specific learning objectives for each of these dimensions, we have provided educators with a framework which can help them organize and implement computer literacy programs. These objectives should help instructors develop more comprehensive and clearly focused instructional computing activities to help their students understand computers and their uses in our society.

## REFERENCES


Amara, R. TOWARD UNDERSTANDING THE SOCIAL IMPACT OF COMPUTERS. Institute for the Future, Menlo Park, CA: 1974.

Bell, D. THE COMING OF THE POST-INDUSTRIAL SOCIETY. New York Basic Books, Inc.: 1973.

Denenberg, S. AN ALTERNATIVE CURRICULUM FOR COMPUTER LITERACY DEVELOPMENT. University of Massachusetts. 1977, p. 97.

Engle, S., & Longstreet, W. Education for a changing society. ASSOCIATION FOR SUPERVISION AND CURRICULUM DEVELOPMENT YEARBOOK: 1978, pp 226-261.

Makar, L. What is computer awareness? COMPUTER EDUCATION, Computer Education Group, British Computer Society, #14: June, 1973, pp. 25-27.

Michael D. THE UNPREPARED SOCIETY. New York Basic Books, Inc.: 1968.

Minsky, M. FORM AND CONTENT IN COMPUTER SCIENCE. ACM Touring Lecture: 1970.

Molnar, A. The next great crisis in American education: computer literacy. THE JOURNAL: July/August, 1978.

Moursund, D. Computer Literacy. OREGON COMPUTING TEACHER, Oregon Council for Computer Education, Vol. 2, #1: October, 1974.

Moursund. D. What is computer literacy? OREGON COMPUTING TEACHER. Oregon Council for Computer Education, Vol. 2, #2: June, 1975, p. 17.

Porat, M. RHW INFORMATION ECONOMY. Department of Commerce, Office of Telecommunications and the National Science Foundation, U.S. Government Printing Office, Washington, D.C.: 1977.

Press, L. Towards general information processing literacy. PROCEEDINGS OF FIFTH ANNUAL CONFERENCE ON COMPUTERS IN UNDERGRADUATE CURRICULA: 1974.

Taylor, R. COMPUTING COMPETENCIES FOR TEACHERS: A PRELIMINARY PROJECTION FOR ALL BUT TEACHERS OF COMPUTERS, Unpublished: 1979.

Weizenbaum, J. COMPUTER POWER AND HUMAN REASON, W. H. Freeman and Co., San Francisco, CA: 1976, p. 278.

CERI - Report Extracts. INTERNATIONAL WORLD OF COMPUTER EDUCATION, Vol 1, #5: 1974.

COMPUTER EDUCATION FOR TEACHERS IN SECONDARY SCHOOLS - AN OUTLINE GUIDE OF THE INTERNATIONAL FEDERATION OF INFORMATION PROCESSING SOCIETIES, Geneva, Switzerland: 1971.

Computers in higher education, REPORT TO THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE, Washington, D.C.: 1967.

The computer Society, TIME: February 20, 1978.

National Council of Supervisors of Mathematics: 1978.

______RECOMMENDATIONS REGARDING COMPUTERS IN HIGH SCHOOL EDUCATION. Conference Board of the Mathematic Sciences, Washington, D.C.: 1972.

# CHAPTER 3

# A SURVEY OF INSTRUCTIONAL ACTIVITIES IN MINNESOTA SCHOOLS

## Chapter 3

## A SURVEY OF INSTRUCTIONAL ACTIVITIES IN MINNESOTA SCHOOLS

Since one of the primary purposes of this research effort was to measure the influence of typical instructional computing activities in schools on the development of an awareness and understanding of computers, a systematic procedure for identifying these activities was needed. The identification and selection of typical activities was accomplished through a statewide survey of all mathematics, science, computer science/data processing and business education teachers. While the results of this survey have been discussed in a recently published article titled "Instructional Computing: Acceptance and Rejection by Secondary School Teachers" (see Appendix A), we have chosen to briefly describe the survey here in order to report the complete effort of our research group. While the basic purpose of the survey was to help us identify and categorize teachers that were teaching about or with computers, the survey represents one of the most comprehensive attempts to explore the role of computers and computing in science education.

Teachers, especially in new and emerging curriculum areas such as computing and computer literacy, have a very signficant influence on the structure and content of instructional programs and approaches. In the absence of clearly defined models and approaches or textbooks to guide their coverage of topics, they play an especially important role in shaping learning opportunities. More than any other single group, the mathematics teachers, and to a lesser degree the science and business education teachers, have been the motivating force behind the introduction of computers in the secondary school setting. In addition to bringing the computer itself into education as a tool, they have been instrumental in the design and implementation of computer literacy programs as we know them today.

## METHOD

A mail questionnaire was developed and distributed in February, 1978, to all 6,837 Minnesota secondary school (grades 7-12) teachers in mathematics, science and business education. The names of the teachers were provided on mailing labels by the Education Data Systems Section of the Minnesota Department of Education and represented the most up-to-date and complete list available. These subject areas were selected because they had the highest proportion of teachers using computers or teaching about computers in their classes.*

The questionnaire, entitled "A Survey About Education and Computers," was purposely brief with one page for all teachers to complete and a second page for teachers involved in computer related activities to describe their involvement. (See Appendix D) After six weeks, there was a follow-up mailing, and a total of 3,576 questionnaires (52 percent) were returned.

To estimate the degree of bias, comparisons were made with all available statistics for the state population of teachers. (See Table 2) Because official records do not distinguish between business education teachers and other vocational teachers, our comparisons are restricted

---

*In addition to this survey, all school principals serving schools with grades 7-12 were contacted and asked to provide the names of teachers in their schools outside of mathematics, science, computer science, data processing and business education who were active in teaching with or about computers. The teachers identified through this process (approximately 550) were contacted using the same survey questionnaire and responses were obtained from 250 teachers in areas such as home economics, social studies, industrial arts, physical education, etc. These teachers were not included in the analysis from which the various approaches to computer use identified because they were not identified through a census and because most of these areas are not traditionally included in science education.

Table 2

COMPARISON OF SURVEY RESPONDENTS
AND MINNESOTA DEPARTMENT OF EDUCATION STATISTICS,*
SECONDARY ONLY MATHEMATICS/SCIENCE TEACHERS

| | | Survey Respondents | State Population Statistics |
|---|---|---|---|
| Years of Teaching | 1 - 10 | 42% | 39% |
| | 11 - 19 | 39 | 41 |
| | 20 + | 19 | 20 |
| | | 100 (2711) | 100 (4748) |
| Gender | Female | 16% | 16% |
| | Male | 84 | 84 |
| | | 100 (2711) | 100 (4748) |
| Teaching Areas | Math | 54% | 54% |
| | Science | 35 | 43 |
| | Math and Science | 11 | 3 ** |
| | | 100 (2711) | 100 (4748) |

* Source is Minnesota State Department of Education, "Planning Agency Reports," June 6, 1978.

** The state records do not separate out those that teach in more than one area. We estimated the number of "math and science" teachers by counting duplicate mailing labels. Our survey asked each teacher to check all "teaching areas." Consequently, our estimates of assignments to multiple areas; i.e., "math and science" are higher than the official statistics.

to mathematics and science teachers (82 percent of our sample). For subject area and gender, the survey and population distributions were almost identical. There was a slight overrepresentation of younger teachers, those having taught 10 years or less, in our sample. However, because the overrepresentation of less experienced teachers amounts to only 3 percent, we have considerable confidence in the representativeness of the sample.

All of the teachers were asked to complete the first page of the questionnaire, which asked for basic information such as teaching area, computer training received, computer resources, etc. and for a response to seven attitudinal statements. The attitudinal data provided valuable information on teacher views of computer use in education and of the importance of computer literacy.

Teachers teaching with or about computers were asked to complete the second page. This information was used subsequently to identify typical and representative instructional computing activities and to establish a list of teachers which could be sampled and asked to participate in the assessment of computer literacy.

## RESULTS

### Computer Use

One of every two (50 percent) teachers in the sample reported that they had used computers at some time in their classes, but only one of every three (33 percent) were still engaged in instructional computing (see Table 3). The percent of dropouts (discontinued computer users) for the entire sample is 17 percent and this is a fairly stable proportion across the subject areas. Current computer use, however, does vary by subject. Forty-three percent of the mathematics teachers were currently engaged in instructional computing but only 19 percent of the science teachers and 28 percent of the business education teachers were so involved.

### Type of Computer Use

Table 4 provides a ranking of the computer-related activities contained on page two of the questionnaire. When ranked on the basis of

Table 3

COMPUTER USAGE STATUS BY TEACHING AREA

| | Current Teaching Area | | | | |
|---|---|---|---|---|---|
| | Math Only | Math & Science | Science Only | Business Ed | Total |
| Current Computer Use | 43% | 42% | 19% | 28% | 33% (1183) |
| Discontinued Computer Use | 18 | 14 | 14 | 19 | 17 ( 599) |
| Never Used Computer | 39 | 43 | 67 | 53 | 50 (1794) |
| Total | 100% (1599) | 100% ( 291) | 100% (1038) | 100% ( 648) | 100% (3576) |

$X^2 = 240.92$, $P < .000$

the number of courses in which the instructional computing activity occurs, instructional simulation is the most frequent activity. Teaching how to operate a terminal, student problem-solving using computers, instructional games, and the teaching of computer programming follow closely behind. Instructional computing activities such as drill, using the "computer as a surrogate instructor" and computer managed instruction are among the least frequent activities in these disciplines.

## Computer Resources

One of the questions asked of the teachers was whether a computer terminal or computer was available for use with their classes. Table 5

Table 4

| NATURE OF COMPUTER USE | NUMBER OF COURSES IN WHICH THE ACTIVITY IS PERFORMED | % OF TOTAL NUMBER OF COURSES LISTED |
|---|---|---|
| 1. RUN SIMULATIONS | 1101 | 41.3% |
| 2. TEACH TERMINAL OPERATION | 1031 | 38.6% |
| 3. STUDENT PROBLEM SOLVING | 992 | 37.2% |
| 4. STUDENT INSTRUCTIONAL GAMES | 991 | 37.2% |
| 5. TEACH PROGRAMMING | 976 | 36.6% |
| 6. TEACH ROLE AND IMPACT | 849 | 31.8% |
| 7. STUDENT LEISURE TIME | 932 | 31.2% |
| 8. AS A CALCULATOR | 759 | 28.4% |
| 9. TEACH COMPUTER APPLICATIONS | 750 | 28.4% |
| 10. TEACH COMPUTER CAREERS | 627 | 23.5% |
| 11. DEMONSTRATE CONCEPTS | 588 | 22.0% |
| 12. TEACH COMPUTER HISTORY | 481 | 18.0% |
| 13. TEACH HARDWARE/SOFTWARE CONCEPTS | 472 | 17.7% |
| 14. DRILL STUDENTS | 449 | 16.8% |
| 15. MATERIALS GENERATION | 436 | 16.3% |
| 16. TEACH DATA PROCESSING PROCEDURES | 372 | 13.9% |
| 17. INFORMATION RETRIEVAL | 328 | 12.3% |
| 18. STUDENT ANALYSIS OF DATA | 322 | 12.3% |
| 19. AS A TUTOR | 254 | 9.5% |
| 20. SCORE TESTS | 197 | 7.4% |
| 21. INSTRUCTIONAL MANAGEMENT | 115 | 4.3% |
| 22. ELECTRONICS INSTRUCTION | 36 | 1.3% |

Note: On the average, five of these activities were checked for each course.

*The total number of all courses reported is 2668.

Table 5

QUESTION: IS A COMPUTER TERMINAL AVAILABLE FOR USE WITH YOUR CLASSES?

| | Users* | Non-Users | All |
|---|---|---|---|
| Yes, Anytime | 35 | 9 | 18 |
| Yes, Sometimes | 51 | 45 | 47 |
| No | 6 | 33 | 24 |
| Don't Know | 1 | 7 | 5 |
| No Response | 8 | 6 | 7 |
| N | 1296 | 2520 | 3816** |

* These teachers teach with and/or about computers in at least one of their classes.

** Includes teachers identified by principals as being teachers outside of mathematics, science, computer science, business education, and data processing areas who teach with or about computers.

shows that 65 percent of the teachers responding had access to a terminal at least some of the time. The users had considerably greater access (86 percent) than did the non-users (54 percent). Another measure of the availability of computer resources was obtained through a question relating to availability for student use. As shown in Table 6, 25 percent of the teachers responded that in their schools no terminals or computers were available for student use. The largest percentage of respondents (38 percent) were in schools where only one terminal or computer was available for student use.

## Computer Training

The teachers were asked whether they had received training about

Table 6

QUESTION: HOW MANY COMPUTER KEYBOARD TERMINALS OR COMPUTERS ARE AVAILABLE FOR STUDENT USE?

| | Users* | Non-Users | Total |
|---|---|---|---|
| 0 | 13% | 32% | 25% |
| 1 | 39 | 37 | 38 |
| 2 | 27 | 19 | 22 |
| 3 | 10 | 8 | 8 |
| 4 | 6 | 3 | 4 |
| 5 | 1 | 1 | 1 |
| 6 or More | 4 | 2 | 2 |
| N | 1296 | 2521 | 3817 |

* Teach with and/or about computers

computers or computer use in education. As Table 7 illustrates, 72 percent of the respondents indicated that they had received some sort of training (including self-training). Training was much more prevalent among the users (92 percent) than the non-users (62 percent).

Another question dealt with the general content of the training received. Almost one-half (46 percent) of the respondents to the question had received some computer programming training through college courses, workshops, self-learning, or other means. Nearly as many respondents (42 percent) had received training in using computers in their discipline (see Table 8).

Table 7

QUESTION: HAVE YOU RECEIVED TRAINING (THROUGH COLLEGE COURSES, WORKSHOPS, SELF-LEARNING) ABOUT COMPUTERS OR COMPUTER USE IN EDUCATION?

| | Users* | Non-Users | Total |
|---|---|---|---|
| Yes | 92% | 62 | 72 |
| No | 8 | 38 | 28 |
| N | 1294 | 2514 | 3808 |

* Teach with and/or about computers

Table 8

HAVE YOU RECEIVED TRAINING (THROUGH COLLEGE COURSES, WORKSHOPS SELF-LEARNING) IN THE FOLLOWING AREAS?

| | YES* |
|---|---|
| Computer Use in Your Discipline | 42% |
| Business Data Processing | 13% |
| Computer Programming | 46% |
| Survey of Computer in Education | 10% |
| Computer Science | 16% |
| Other | 4% |

* Multiple responses were possible. Based on 3808 respondents.

## Teacher Attitudes Toward Computing

In an effort o measure the teacher's attitudes toward computing, they were asked to indicate their degree of agreement or disagreement with seven statements. Table 9 and Figure 3 show the responses of the users/non-users to these statements.

The responses indicated strong support for the need for general, minimal computer literacy among secondary school students. Eighty-five percent of the respondents agreed or strongly agreed with the statement that "every secondary school student should have some minimal understanding of computers" (Item 1). An even larger number of respondents (93 percent), agreed that "every secondary school student should learn about the role that computers play in our society" (Item 3).

Only 27 percent of the respondents thought that "every secondary school student should be able to write a simple program" (Item 2). Nearly 45 percent of the teachers disagreed with this statement, while 29 percent were undecided.

Two of the statements (items 6 and 7) dealt with the teacher's perception of the general value of computers in education. Their responses show that the teachers generally felt very positive toward the use of computers in education. Eighty-seven percent agreed that computers could be a useful instructional aid in many subject areas other than mathematics. While historically the computer has found its greatest acceptance in mathematics courses, the respondents see its value in other subject areas as well. In addition, the majority (69 percent) of the teachers supported use of computers in education by disagreeing with the statement that computers provide more disadvantages than advantages in education. Only 8 percent agreed with the statement, while 23 percent were undecided.

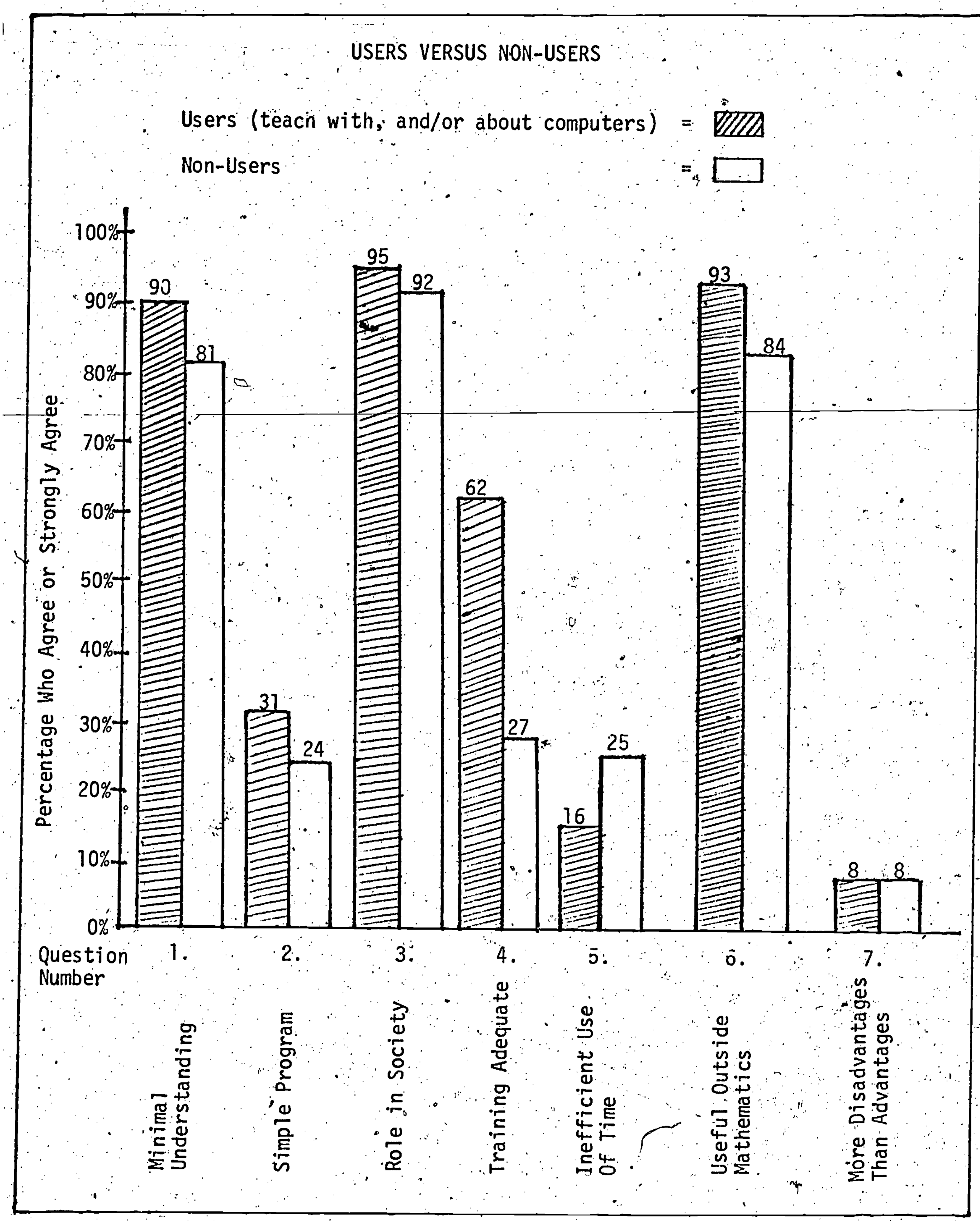
Table 9

USERS VERSUS NON-USERS

| STATEMENT | | STRONGLY DISAGREE % | DISAGREE % | UNDECIDED % | AGREE % | STRONGLY AGREE % | n |
|---|---|---|---|---|---|---|---|
| 1. EVERY SECONDARY SCHOOL STUDENT SHOULD HAVE SOME MINIMAL UNDERSTANDING OF COMPUTERS. | USERS | 1 | 4 | 5 | 45 | 45 | 1291 |
| | NON | 2 | 8 | 9 | 57 | 25 | 2511 |
| | ALL | 1 | 7 | 7 | 53 | 32 | 3802 |
| 2. EVERY SECONDARY SCHOOL STUDENT SHOULD BE ABLE TO WRITE A SIMPLE PROGRAM. | USERS | 6 | 36 | 26 | 26 | 5 | 1290 |
| | NON | 9 | 37 | 30 | 21 | 3 | 2509 |
| | ALL | 8 | 37 | 29 | 23 | 4 | 3799 |
| 3. EVERY SECONDARY SCHOOL STUDENT SHOULD LEARN ABOUT THE ROLE THAT COMPUTERS PLAY IN OUR SOCIETY. | USERS | 1 | 1 | 3 | 54 | 41 | 1289 |
| | NON | 1 | 2 | 6 | 64 | 28 | 2510 |
| | ALL | 1 | 2 | 5 | 61 | 32 | 3799 |
| 4. MY TRAINING HAS ADEQUATELY EQUIPPED ME TO MAKE DECISIONS ABOUT USING COMPUTERS IN MY TEACHING. | USERS | 4 | 18 | 17 | 47 | 15 | 1287 |
| | NON | 16 | 40 | 17 | 23 | 4 | 2494 |
| | ALL | 12 | 32 | 17 | 31 | 8 | 3781 |
| 5. THE EFFORT NECESSARY TO INTEGRATE COMPUTERS INTO MY TEACHING IS AN INEFFICIENT USE OF MY TIME. | USERS | 16 | 47 | 22 | 12 | [illegible] | 1286 |
| | NON | 6 | 29 | 40 | 19 | 6 | 2485 |
| | ALL | 9 | 35 | 34 | 17 | 5 | 3771 |
| 6. COMPUTERS CAN BE A USEFUL INSTRUCTIONAL AID IN MANY SUBJECT AREAS OTHER THAN MATHEMATICS. | USERS | 1 | 1 | 6 | 51 | 42 | 1288 |
| | NON | 1 | 2 | 13 | 63 | 21 | 2507 |
| | ALL | 1 | 1 | 11 | 59 | 28 | 3795 |
| 7. COMPUTERS PROVIDE MORE DISADVANTAGES THAN ADVANTAGES IN EDUCATION. | USERS | 30 | 51 | 11 | 5 | 3 | 1279 |
| | NON | 15 | 20 | 29 | 6 | 2 | 2500 |
| | ALL | 20 | 49 | 23 | 6 | 2 | 3779 |

* "USERS" TEACH WITH, AND/OR ABOUT COMPUTERS

Figure 3


USERS VERSUS NON-USERS
Users (teach with, and/or about computers) =
Non-Users =
Percentage Who Agree or Strongly Agree
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
90
81
31
24
95
92
62
27
16
25
93
84
8
8
Question Number
1.
2.
3.
4.
5.
6.
7.
Minimal Understanding
Simple Program
Role in Society
Training Adequate
Inefficient Use Of Time
Useful Outside Mathematics
More Disadvantages Than Advantages

An additional attitude statement attempted to gauge whether teachers felt using computers in the classroom was worth the effort (Item 5). Forty-four percent of the respondents disagreed with the statement that "the effort necessary to integrate computers into my teaching is an inefficient use of my time." Sixteen percent of those who taught with and/or about computers (users) agreed with the statement, while 25 percent of the nonusers agreed.

Teachers were also asked to respond to a statement reflecting the adequacy of their training related to computers (Item 4). Forty-four percent, or nearly one-half of all teachers disagreed with the statement that "my training has adequately equipped me to make decisions about using computers in my teaching." Only 22 percent of the users disagreed with the same statement, while 56 percent of the non-users disagreeed. Similarly only 27 percent of the non-users agreed that their training was adequate to make the decisions, while 62 percent of the users agreed. (See Table 8)

## SUMMARY

It is evident from these data that teachers strongly support minimal understanding of computers and their societal role for every secondary school student, that they generally feel positive about the value of computers in education, and that they generally feel positive about the value of computers in education. In terms of their own literacy regarding computers, many of them feel inadequately prepared to make decisions about using computers. A comparison of teachers currently using or teaching about computers with other teachers shows that users see their training regarding computers in education as much more adequate than non-users. Those interested in a more complete analysis of these data are referred to the paper contained in Appendix A.

# CHAPTER 4

## A FIELD STUDY ON THE IMPACT OF SCHOOL COMPUTING ACTIVITIES ON STUDENT ATTITUDES AND KNOWLEDGE

Chapter 4

# A FIELD STUDY ON THE IMPACT OF SCHOOL COMPUTING ACTIVITIES ON STUDENT ATTITUDES AND KNOWLEDGE

Computer literacy is being recognized by a growing number of educators at all levels of education as an important educational goal. This, in turn, has spawned numerous instructional efforts designed to introduce students to computers and to improve student awareness and understanding of computers and of their use, misuse and impact. Most of these well-intentioned efforts are implemented in the absence of a clear understanding of the computer literacy levels of entering students, with little information concerning the potential impact of computing activities on the development of computer-related knowledge and attitudes, and without a clear statement of the intended results.

In an attempt to help establish the necessary conceptual and empirical foundation upon which effective computer literacy programs can be built, we conducted a field study designed to help establish baseline data regarding student computer literacy and to determine the relative impact of various instructional computing activities on the development of computer literacy.

This study was organized around two basic research questions:

1. What is the computer literacy level of students both when they enter and when they leave courses with instructional computing activities? At those times, what do they know and feel about computers?
2. What are the relative contributions of typical instructional computing activities to the development of computer literacy?

This chapter describes the methods and results of our effort. We believe that the value of this research is to be found as much in the definitions and data collection instruments as in the actual data produced. The Computer Literacy Questionnaire (Appendix E) which was developed to measure student knowledge and attitudes, has already been used in various parts of the country to help determine the need for and impact of computer literacy programs. In addition, the objectives-based definition of computer literacy which provided the framework for the development of the assessment instrument has been used to help plan and structure computer literacy programs in numerous school districts. We trust that these products will continue to be of practical benefit to classroom teachers. Also, we believe that the baseline data on student computer literacy and the information regarding the impact of instructional activities will help to provide direction and focus to this rapidly expanding area of science education.

## COMPUTER LITERACY OBJECTIVES

The development of a comprehensive set of computer literacy objectives was the first step in our research effort. These objectives, which are listed in Chapter Two, were developed to provide a structure for the development of a computer literacy assessment instrument. We felt that the assessment instrument should be comprehensive and systematic and that the only way this goal could be achieved was by creating a definition of computer literacy expressed in concrete learning outcomes. This list of objectives, in addition to aiding us in the development of an assessment instrument, provides the consumers of our research with the operational definition of computer literacy. The assessment instrument is not simply a loose collection of test items but also a structured test with specific sub-tests matched to specific learning outcomes. This approach to the definition and measurement of computer literacy is flexible enough to accomodate different definitions, yet it provides a functional way of linking the concept to the measurement of its various dimensions. Rather than arguing about the "best" definition of computer literacy, an activity which has little practical payoff, this approach allows us to begin to assess literacy levels and the impact of learning activities.

We began the development of the objectives by collecting information regarding current instructional programs which have computer literacy as a major goal so that we could examine the complete range of instructional programs involving computer use or having some objectives related to learning about computers. A brief statement requesting such information was published in a number of publications reaching teachers likely to be using computers. This strategy yielded responses from a number of educators from across the country. Most of them provided a course outline, a list of course objectives, a description of the topics and the content covered, a statement concerning the length of the course or unit, a description of the student population for which the course or unit was intended and, in some cases, a copy of the tests used.

In addition, we contacted all of the institutions identified by HumRRO as offering high quality programs in this area as well as other school districts, schools and teachers known by the research team to be active in the area of computer use and computer literacy.

These efforts produced a large collection of instructional materials and course/unit descriptions which were useful in defining the boundaries of current practice vis-a-vis computer literacy. This information also helped in identifying the various dimensions of the concept.

Following the systematic and time-consuming examination of several hundred textbooks, teacher-developed materials, curriculum guides, course outlines and over 2,000 individual test items, a tentative list of topics, which we felt reflected the various dimensions of computer literacy, was established. This list was revised several times and finally translated into a list of learning objectives which more closely defined the intended outcomes of computer literacy. These objectives were reviewed and revised a number of times by the project team and finally sent to a carefully selected group of experts representing the professional computer societies, the computer industry, and the field of education for their review and criticism. Following this review the project team developed the final working version of the objectives.

It is important to note that these objectives are informational objectives. While some are stated rather specifically, explicitly designating a desired outcome, for the most part they are not "behavioral" but represent guides for the construction of test items and for the organization of content of instructional programs. Since the data collection would involve the testing of secondary school students, there was also a need to try to reduce the complete set to some smaller subset which could be assessed in a reasonable period of time - about 30 minutes. Thus the list contains a number of "core objectives" (marked with an "*") which represent the objectives used as the basis of our assessment effort. In general, the experts who reviewed the objectives suggested that while the core objectives were appropriate for the research task, there was a need to further extend and refine this set to access higher levels of cognitive skills and understanding. We agree the reader should not attach the notion of "minimum competency" to this core set, but rather recognize that this represents a viable and manageable set for an initial assessment of computer literacy.

## THE COMPUTER LITERACY QUESTIONNAIRE

Since the primary objective of this research was to assess student knowledge and attitudes and to measure learning gains associated with differing types of classroom experiences involving computer and/or computer topics, we needed a comprehensive and empirically validated measurement instrument which could be used to gauge a wide range of expected learning outcomes.

Efforts to construct assessment instruments and measure computer literacy to date have been limited in scope and are largely unsystematic. Perhaps the most systematic effort in this area to date was that of the National Assessment of Educational Progress (NAEP). As a part of the planning for the 1977-78 assessment of mathematics, the NAEP staff assembled a group of computer educators to help them define a strategy for assessing computer-related knowledge. This group spent considerable time defining the areas of computer literacy to be assessed and produced a definition of computer literacy with a related set of specific assessment items. Much of this work was never used, however, due primarily to the lack of time within the total mathematics assessment effort. Our research team reviewed the NAEP work and built upon it. The NAEP effort was the most comprehensive and systematic to data and our efforts complement and extend their initial work.

Most existing tests of computer literacy are much less comprehensive or systematic than we would like. A number of such tests have been published in the popular literature of instructional computing but they are not designed to be comprehensive assessment tools, nor have they been empirically validated. This type of computer literacy test is useful to the degree that it helps science educators organize the content and scope of computer literacy or helps classroom teachers construct criterion-referenced tests, but such tests are not very useful to those interested in doing systematic research.

Teacher-made tests of computer literacy represent another effort to measure computer literacy but they are most often designed to measure student knowledge imparted in conjunction with a specific course or instructional unit. While this type of testing was of interest to us and numerous classroom level tests were collected and analyzed, it did not add much to the development of the Computer Literacy Questionnaire.

Since a comprehensive, systematic and empirically validated computer literacy assessment instrument did not exist, our research team devoted extensive effort to the development and validation of such a measurement device. The result of this effort was a two-part assessment instrument which we titled the Computer Literacy Questionnaire. (See Appendix E) Part I of the instrument includes items used to form eight attitude scales: (1) Enjoyment, (2) Anxiety, (3) Efficacy, (4) Sex-typing, (5) Policy Concern, (6) Educational Computer Support, (7) Value 1 (Social), and (8) Value 2 (Technical). Part II contains 49 test items of five cognitive areas: (1) Hardware, (2) Programming and Algorithms, (3) Software and Data Processing, (4) Applications, and (5) Impact. The subtest scores for these five cognitive areas were combined to produce a composite measure of cognitive computer literacy.

The questionnaire represents a major product of this research effort and it is the subject of a separate validation report. (See Appendix F) We would urge the reader at this point to read this report to gain a more complete view of the nature of this measurement instrument.

One third of the teachers (1183) responding to our survey reported teaching one or more classes which included the use of the computer or some type of computer-related subject matter. In total, 2668 specific courses were reported as including the computer or computer topics in some way.

While each of these courses represents a unique mixture of teacher-defined topics and activities, our research plan called for the placement of these courses into homogeneous categories based upon the nature of the instructional computing activities involved. Specific classes could then be randomly selected to represent each course category. Four specific categories of instructional computing courses were established: Programming, Computer Appreciation, Computer Studies, and Computer Assisted Instruction. These categories are described below. (See also Appendix G)

Programming (P)

This general category of courses centered around the development of knowledge of computer systems and programming skills. Students were exposed to the elementary principles of computer science and taught to program in a computer language like BASIC.

In order to be placed in this category, a course/unit:

a) Had to contain a programming emphasis,

b) Could not include any significant instructional material on the role and impact of computers in society,

c) Might include any other instructional computing activity.

Fourteen percent (374) of the 2668 courses identified met these criteria and were placed in this category. Seventeen (17) of these courses were randomly selected to represent this category. The course names and the distribution of courses are shown in Table 10. In all

17 courses, students were taught to program in the BASIC language. Most of the problems that the students were assigned to solve were of a mathematical nature. In addition to programming, the students often ran game and simulation programs found on available computer timesharing system libraries.

The first six courses listed were devoted totally to computer topics. These courses generally met for 90 hours between pre- and post-testing. The main function of these courses was to teach the students to program the computer.

The remaining eleven courses in the programming category were all mathematics courses that included programming as a topic. In two of the courses, only five hours were spent on computer topics, so the coverage was not extensive. However, in most of these mathematics courses, 15-20 hours were devoted to computer topics, primarily programming.

Table 10

PROGRAMMING

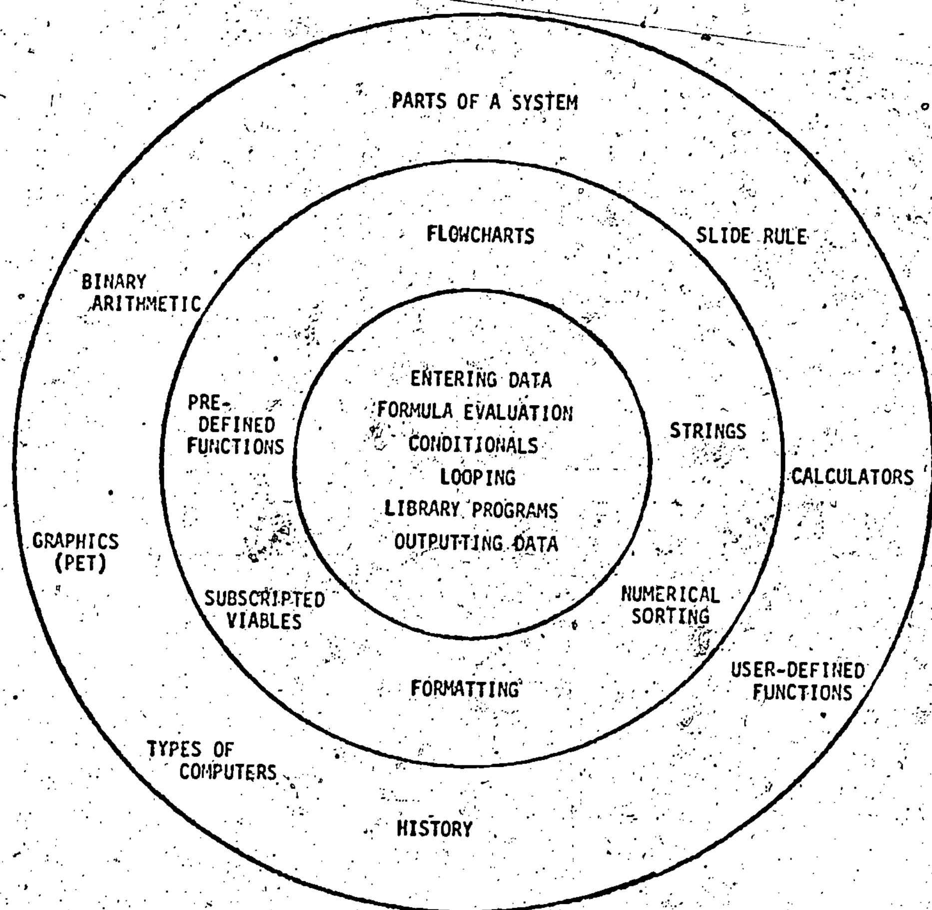
| Courses | Number |
|---|---|
| Computer Science I | 1 |
| Computer Insights | 1 |
| Computer Programming | 2 |
| Beginning BASIC | 1 |
| Basic Computer | 1 |
| Advanced Math | 2 |
| Advanced Algebra | 1 |
| Math 8 | 1 |
| General Math 9 | 1 |
| Accelerated Math 7 | 1 |
| Algebra 1 | 2 |
| Geometry 2 | 2 |
| Probability and Statistics | 1 |
| | 17 |

As required by the classification procedure, none of these courses contained any significant coverage of the role and impact of computers in society. In some of the courses, however, brief mention was made of computer applications but no organized effort to include such topics was evident.

Figure 4 illustrates the major computer topics and instructional activites found in this category. The topics shown in the inner circle were taught in all of the courses, while those farthest from the center (the outer circle) are topics that were present in only a few of the courses.

Figure 4

MAJOR TOPICS/ACTIVITIES: PROGRAMMING




## Computer Appreciation (CA)

This category of courses reflects an effort to develop an understanding of the general use and impact of computers in society. Courses in this category tended to emphasize the non-technical aspects of computer capabilities; the social, vocational, educational uses of computers, public attitudes toward computers; and miscellaneous computer applications.

In order to be placed in this category, a course/unit:

a) Had to include the role and impact of computers as a topic,

b) Could not involve computer programming,

c) Might include other computer activities.

This category was in effect opposite of the previous one.

Ten percent (267) of the computer courses identified in the teacher survey were categorized as computer appreciation courses or as containing computer appreciation units. Six of such courses were selected to represent this category. (See Table 11)

Table 11

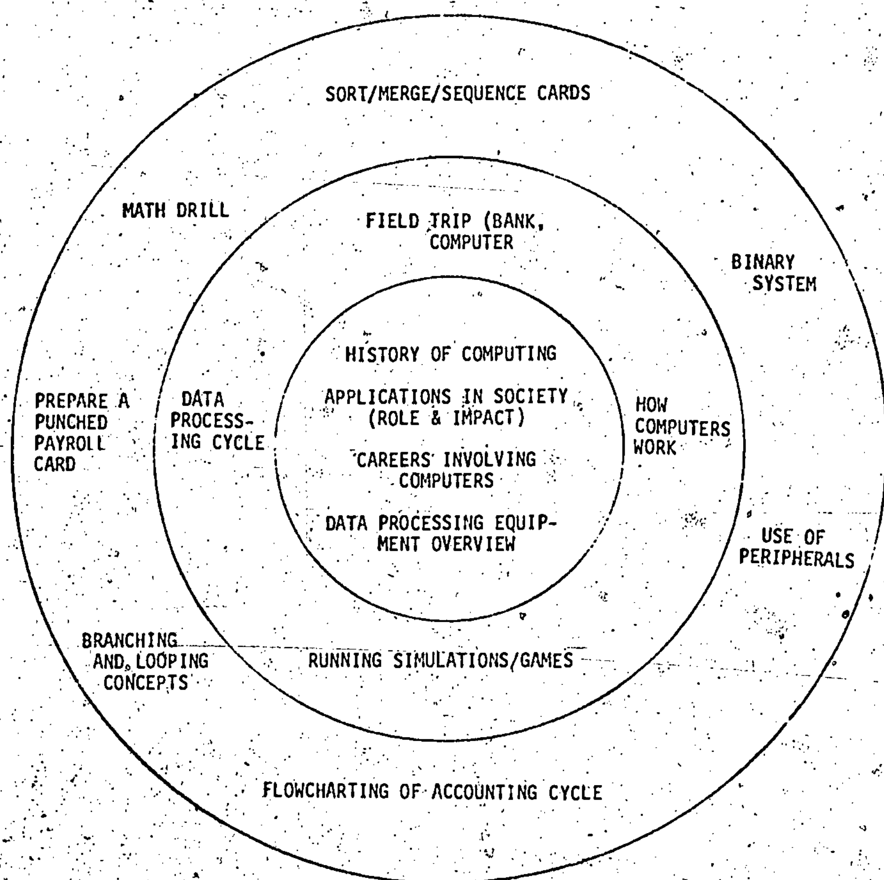
| COMPUTER APPRECIATION Courses | |
|---|---|
| Advanced Bookkeeping | 1 |
| Office Education | 1 |
| Clerical | 1 |
| Office Practices | 1 |
| Math 7 | 1 |
| Math 8 | 1 |

The major computer topics/activities found in these courses are shown in Figure 5. In none of the four business courses did the teachers or students actually use a computer. Typically, field trips were taken to businesses that used computers for data processing. Also, the general role of computers in society (particularly in business) was discussed. The main emphasis was on elementary data processing. In two of these courses, the total time spent on data processing and computer topics was only 5 hours. In the third course over 15 hours were spent on data processing topics, with considerable emphasis on computer use.

In the two mathematics classes, the students used the computer to run game and drill practice programs. The teachers also discussed the history of computers, applications in business, etc., and the impact of computers in society. The expressed purpose of the computer material

Figure 5

MAJOR TOPICS: COMPUTER APPRECIATION




was to promote students' interest in computers. The extent of coverage of computer topics differed considerably between the two mathematics courses. One course spent only six hours on computer topics, while the other course spent about 30 hours.

## Computer Studies (CS)

This category contained courses and instructional units that combined computer programming with instruction on the role and impact of computers in society. In other words, it combined the two previous approaches: programming and computer appreciation.

The exact nature of the mix of these two strands seemed to depend on the background and training of the teacher. If the teacher taught mathematics or computer science, it was more likely that the learning activities would be organized around programming and computer science topics. If the teacher was in business education, the course was more likely to emphasize the social applications and implications of computers.

Courses in this category:

a) Had to include programming,

b) Had to include coverage of the role and impact of computers,

c) Could include any remaining computer activities.

Nineteen percent (507) of the computer courses identified in the teacher survey belonged in this category. Ten courses were randomly selected to represent this category. (See Table 12) The students in all of these courses received some instruction in BASIC language programming. However, unlike the courses in the Programming category, there was an organized attempt on the part of the instructor to teach students about the role and impact of computers in society as well. These topics were covered with the help of general discussions, field trips, and the viewing of films about the role and impact of computers. Students also wrote simple application programs.

Table 12

| COMPUTER STUDIES Courses | Number |
|---|---|
| Computer Science | 3 |
| Computer Programming | 2 |
| Introduction to Computers | 2 |
| Data Processing | 1 |
| Math 7 | 1 |
| Math 8 | 1 |
| | 10 |

Figure 6 illustrates the more prevalent computer topics/activities found in the courses. Those topics in the inner-most circle were found in all of the courses, with more extensive coverage in the eight computer courses than in the two mathematics courses. The mathematics courses averaged about 20 hours on computer topics, while the remaining courses allotted considerably more hours to computer topics.

Computer Assisted Instruction (CAI)

This category included courses which used computers as instructional tools. It did not, as such, include any formal attempt to cover computer topics. It was included in our research design since it has been suggested that CAI produces some increased awareness and understanding of computers as a by-product. If this is true, then CAI does represent an approach to the development of computer literacy.

In order to be classified in this category, the course:

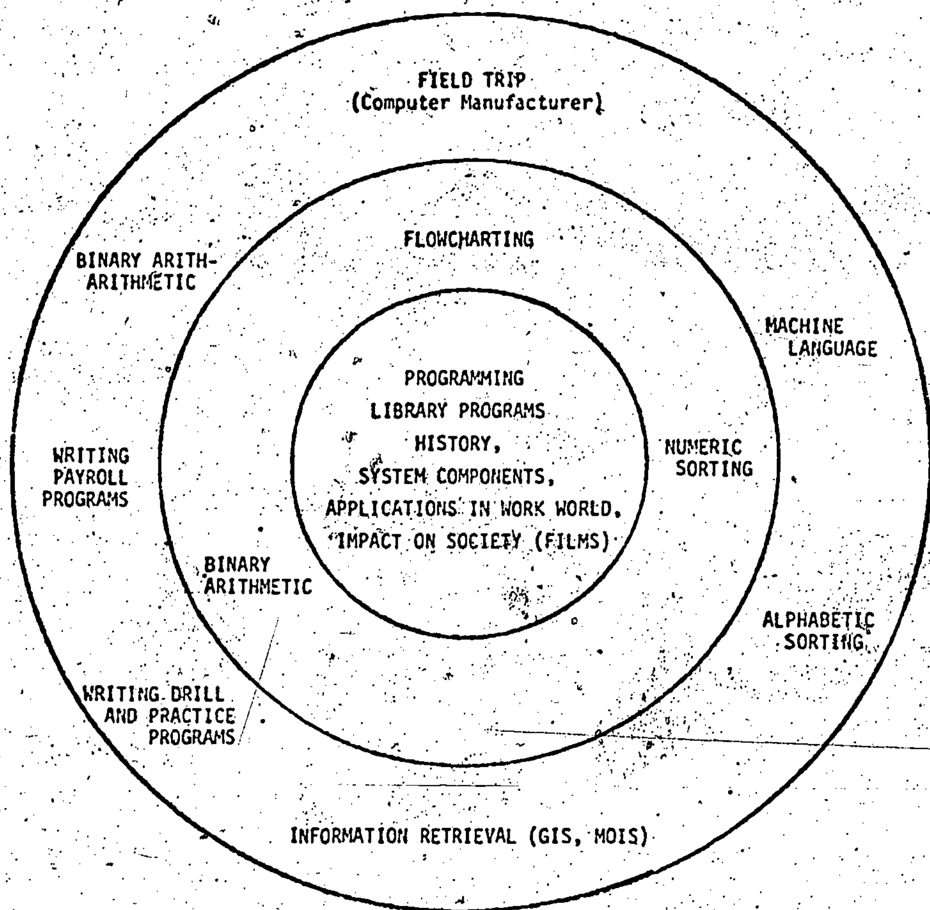
a) Had to include either simulation, drill, or tutorial activities,

b) Did not involve any programming activities or instruction on social impact of computer,

c) Could include any other computer-activities.

Figure 6

MAJOR TOPICS: COMPUTER STUDIES




Twenty percent (543) of the courses in the survey were placed in this category. Ten of these courses were randomly chosen to represent computer assisted instruction in the field study; the course names and frequencies are shown in Table 13. Six of the courses are in the science area. The students in these courses used the computer to run content related simulations, drills, and tutorial programs.

The following were frequently used CAI programs: NEWTN2 (Escape from Devil's Island using Newton's 2nd law); HEATLOS, which analyzes home heat losses; ODELL, which simulates a food chain in a lake; COMMUN,

Table 13

| CAI Courses | Number |
|---|---|
| Physics | 3 |
| Physical Science | 1 |
| Ecology | 1 |
| Biology | 1 |
| Title I Mathematics | 1 |
| Mathematics 7 | 1 |
| Mathematics, General | 1 |
| Social Studies | 1 |
| | 10 |

a tutorial on ecosystem concepts; and ENERGY, which simulates energy policy decision making. The students did not do any programming in these classes. There was a considerable range in the number of hours of class time devoted to computer use. The smallest amount of time spent on computer topics was 2 hours and the largest was 30 hours.

## DATA COLLECTION

The field study involved the administration of the Computer Literacy Questionnaire (Appendix E) to students in 51 carefully chosen classrooms. The teachers asked the students to complete the Questionnaire either before or at the beginning of the instructional computing activity and the teachers readministered the Questionnaire after the computing activity was completed. As explained in the previous section, the classes were sampled on a stratified, random basis from a list of over 2,600 classes. Classes were randomly sampled from each of the four categories of instructional computing courses (Programming, Computer Appreciation, Computer Studies, and CAI) and each grade level (junior high and senior high). Thus, there were eight groups of classes from each of which approximately 12 classes were drawn. Our sampling procedure did not allow a teacher to be included more than once.

The teachers of the selected courses were contacted to determine whether or not they were still teaching the course described in the Teacher Survey and to obtain their cooperation in administering the Computer Literacy Questionnaire. The teachers were offered a $50 honorarium for their participation and asked to administer the Questionnaire, including the computer literacy tests at the beginning and at the end of their course, or instructional unit, involving computers. In order to have a detailed record of the instructional process between the pre and post-tests, the participating teachers completed a weekly log sheet containing information regarding course objectives, computer use, computer topics, materials used, etc. In addition to the log sheets, the teachers completed a lengthy questionnaire at the end of the field study. (See Appendix H for a copy of the log sheet and end of course questionnaire.)

The log sheets and questionnaires were used to determine whether the classification of the courses was accurate and to provide a detailed summary of typical instructional activities and objectives.

Teachers were asked not to look at the Questionnaire themselves until they had administered the post-test. The pretest was given to the students with a brief explanation of its purpose and instructions on how to record their answers. No further reference was made to the study until after the administration of the post-test. The teachers were instructed not to adjust the content of their course because of the study and spot checking indicated that they followed this request.

Since a number of teachers had taken new jobs or no longer taught the designated course, a number of classes were, of necessity, dropped from the sample. Several classes were reclassified when it became apparent that the actual classroom approach was different from the planned approach.

In addition to the classes involving computer use as topics, several "control" or comparison classes were tested for comparison purposes. The seven classes which we call "control" classes did not include any computer activities or formal, planned instruction concerning computers. Teachers who were already participating in the study as teachers of "computer" classes were asked to also administer the tests at the beginning and ending of another of their classes not involving any computing activities as topics.

The total sample contained 46 classes (929 students) engaged in instructional computing activities. We will, for the sake of communication, call these classes "computer classes" even though most do not use the term computer in the course title.

The pretesting of the students took place in late August and early September, 1978. Even if the instructional computing activity did not occur until later in the term, the pretesting was completed by the middle of September. Over 1,400 students in grades 7-12 were pretested using the Computer Literacy Questionnaire.

Table 14 lists the number of classes and students involved in each of the instructional categories of the field study. The final sample size was reduced somewhat because some students were absent on the day of the post-test or had dropped the class or left school. One entire class was dropped because the computer component was cancelled due to the unavai[illegible]y of a computer terminal. In spite of these attrition problems, the testing and retesting was completed on 1,106 students in 51 classes.

It is our belief that the sample of 46 computer classes is representative of Minnesota high school classes with instructional computing

Table 14

FIELD STUDY SAMPLE

| Approach | No. of Classes Jr. H.S. | Sr. H.S. | Combined | No. of Subjects/Students Jr. H.S. | Sr. H.S. | Combined |
|---|---|---|---|---|---|---|
| Computer Assisted Instruction (CAI) | 5 | 5 | 10 | 104 | 101 | 205 |
| Programming (PR) | 10 | 9 | 19 | 207 | 171 | 378 |
| Computer Appreciation (CA) | 2 | 3 | 5 | 46 | 50 | 96 |
| Computer Studies (CS) | 4 | 6 | 10 | 169 | 81 | 250 |
| "Control" (C) | 4 | 3 | 7 | 123 | 54 | 177 |
| TOTAL | 25 | 26 | 51 | 649 | 457 | 1106 |

components in 1978. While our stratified sample of classes excluded 33 percent of the classes identified in the teacher sample, most of these contained only minimal computer activities. For example, many teachers indicated that computer test scoring as the only computer related activity in which their class was involved. The distribution of the remaining computer classes is fairly close the distribution across different types of instructional computing in our sample of selected classes. The distribution of our sample of 46 classes does differ slightly in one respect. The number of programming classes in our sample is slightly higher than the relative number of programming classes found in the teacher survey. This is probably due to the tendency for programming classes to be more permanent and to have continuity from year to year. If so, these courses probably have an especially important role in the curriculum and perhaps deserve to be weighted more in the investigation. In any event, the proportion of programming classes in our sample is only slightly higher, so the departure is not serious, and we are confident that the sample of 46 classes is generally representative of classes employing instructional computing techiques.

## RESULTS

The responses of the 929 students who had been exposed to instructional computing activities; i.e., attended computer classes, will be reported first. After summarizing the findings within each of the five cognitive areas and each of the eight attitudinal areas, the performance of students on the "composite" computer literacy test will then be presented. Following this will be the comparisons, using analysis of variance, among the alternative instructional computing approaches. Finally, with the aid of multiple regression, we explore alternative explanations for the differences we find among the approaches.

### Cognitive Computer Literacy

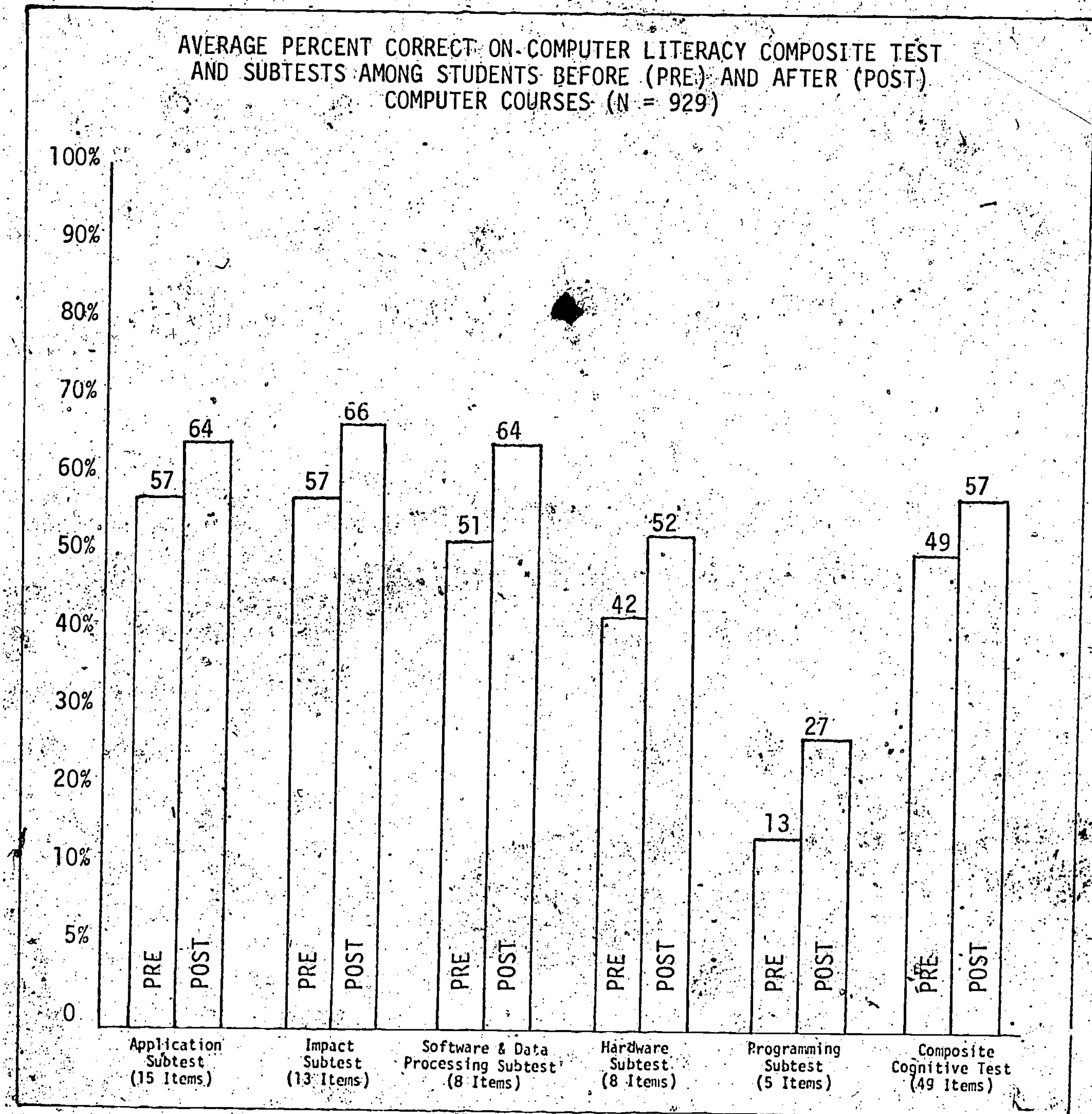
The results for each subtest are presented in Figure 7 with the average percent correct for the subtest corresponding to each dimension of computer literacy. In these data and other data reported in this section, all students are included except for those in "control" classes.

### Hardware

In general, the students did not seem to understand much about the essential functions of a computer. In addition, most of the students did not know the meaning of some basic terms such as hardware and software. For example, initially (at pretest) only 25 percent answered this item correctly:

35. The physical parts of a computer are referred to as:
    a) programs
    b) hardware
    c) software

Figure 7


AVERAGE PERCENT CORRECT ON COMPUTER LITERACY COMPOSITE TEST AND SUBTESTS AMONG STUDENTS BEFORE (PRE) AND AFTER (POST) COMPUTER COURSES (N = 929)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
5%
0
57
64
57
66
51
64
42
52
13
27
49
57
PRE
POST
Application Subtest (15 Items)
Impact Subtest (13 Items)
Software & Data Processing Subtest (8 Items)
Hardware Subtest (8 Items)
Programming Subtest (5 Items)
Composite Cognitive Test (49 Items)

d) manuals

e) I don't know

By the end of their computer classes, 49 percent answered this question correctly; i.e., selected the answer "b." Even so, the low performance on this item indicates that many, if not most, of the students had not learned the basic difference between hardware and software. As shown in Figure 7 and Table 15, the average performance on the hardware knowledge subtest was relatively low: 3.41 items out of 8 items correct at pretest, and 4.32 out of 8 items correct at post-test. The hardware knowledge subtest consists largely of vocabulary and recall material. The low performance level in this area indicates that many teachers may not give much coverage to this type of material.

Programming/Algorithm

The vast majority of secondary school students in our sample could not prepare computer programs. At the initial testing, 20 percent claimed to have written a computer program, but less than 10 percent were able to answer any of the three programming exercises correctly. By post-testing, however, 20 percent answered at least one programming exercise correctly. These findings should be considered from a different perspective; i.e., an alternative percentage base. If we eliminate the non-respondents by ignoring those students who answered "I don't know" or who gave no response at all, the average percent correct for the programming items at pretest was 30 percent and at post-test was 45 percent.

The average performance on all programming and algorithmic items combined was only 13 percent at pretest but climbed to 27 percent at post-test. (See Figure 7) While the rise in programming/algorithm

Table 15

KNOWLEDGE AND ATTITUDE SCALE SCORES
FOR PRE AND POST-TESTING OR COMPUTER CLASSES
(N = 929)

| | No. of Items | | Pre | Post |
|---|---|---|---|---|
| Hardware Knowledge | 8 | $\bar{x}$ | 3.41 | 4.32 |
| | | SD | 1.75 | 1.78 |
| Programming/ Algorithms | 5 | $\bar{x}$ | .60 | 1.21 |
| | | SD | .87 | 1.20 |
| Software & DP Knowledge | 8 | $\bar{x}$ | 4.10 | 5.14 |
| | | SD | 2.21 | 2.27 |
| Applications Knowledge | 15 | $\bar{x}$ | 8.58 | 9.57 |
| | | SD | 3.15 | 2.99 |
| Impact Knowledge | 13 | $\bar{x}$ | 7.46 | 8.53 |
| | | SD | 2.87 | 2.85 |
| Knowledge Composite | 49 | $\bar{x}$ | 24.19 | 28.91 |
| | | SD | 9.05 | 9.21 |
| Computer Enjoyment | 5 | $\bar{x}$ | 18.59 | 18.99 |
| | | SD | 3.57 | 4.12 |
| Computer Anxiety | 5 | $\bar{x}$ | 11.11 | 10.53 |
| | | SD | 3.31 | 3.48 |
| Computer Self-efficacy | 5 | $\bar{x}$ | 16.52 | 17.24 |
| | | SD | 3.04 | 3.46 |
| Computer Sex-typing | 5 | $\bar{x}$ | 10.44 | 10.04 |
| | | SD | 3.21 | 3.29 |
| Policy Concern | 5 | $\bar{x}$ | 18.42 | 18.86 |
| | | SD | 2.64 | 3.16 |
| Educational Computer Support | 5 | $\bar{x}$ | 19.09 | 19.77 |
| | | SD | 2.95 | 2.99 |
| Social Value Orientation | 5 | $\bar{x}$ | 13.82 | 13.93 |
| | | SD | 1.41 | 1.43 |
| Technical Value Orientation | 4 | $\bar{x}$ | 11.28 | 11 49 |
| | | SD | 1.85 | 1.94 |

knowledge/skill associated with the computer classes was substantial, the post-test scores indicate that the level of understanding was still relatively low for the entire sample of students.

## Software and Data Processing

Student knowledge of software and data processing terminology was greater than might be expected on the basis of the findings presented thus far. At pretest, 56 percent correctly identified the definition of "computer program" and 31 percent correctly identified the definition of "data processing." Consider a typical question in the software/data processing area:

42. Computer processing of data may involve:

    a) searching

    b) summarizing

    c) deleting

    d) all of the above

    e) I don't know

Initially (pretesting) 50 percent selected "d," the correct answer, and by post-testing 58 percent gave the correct response. Through a combination of prior knowledge and learning in computer courses, most students apparently acquired a general understanding of some elementary concepts of data processing and software. On test items in this area, students, on the average, answered 51 percent correctly at pretest and 64 percent correct at post-test.

## Applications

Most students enter computer-related courses knowing that computers are widely used in many ways. For example, 66 percent answered the following correctly:

9. Computers have been used to make more information and products available to the consumer. (true/false/I don't know).

At the end of their computer courses, 76 percent answered it correctly. Performance was lower on the more specific questions, but the overall performance in the applications area was 57 percent (correct) at pretest and 64 percent at post-test.

Impact

The students generally seemed well aware of the pervasive impact of computers on society. This awareness extends to problems of employment (item No. 14) and privacy (item No. 13). Again, student performance was lower on the more specific items; e.g.,

10. Computers are used to commit serious crimes, especially stealing money and stealing or falsifying information. (true/false/I don't know).

Only 30 percent answered "true," the correct response, at pretest but 44 percent did so at post-test. The overall average performance in this area was nearly identical in level to that of the applications area.

Computer Enjoyment

The extent to which a person says they enjoy or enjoy learning about computers was measured by a five item attitude scale. Like most of the other attitude items, each item required one of the following responses:

1) strongly disagree
2) disagree
3) undecided
4) agree
5) strongly agree

Since the scale score for each person was derived by adding together the responses to each of the five items, the attitude ranged from a minimum of 5 to a maximum of 25. A score, or average score, of 15 would imply an equal number of agreement and disagreement responses. The computer enjoyment level for all 929 students at pretest averaged 18.59 but at post-test averaged 18.99. This gain in attitude is small but statistically significant using the 0.01 level criterion with the t-test. (The gain for all of the measures of both cognitive and affective computer literacy was statistically significant using this criterion.) These findings indicate that while the students entering computer classes were generally quite positive toward computers, they became even more positive during their experiences in computer courses.

## Computer Anxiety

Another set of five items expressed the opposite or counter attitude to enjoyment. This scale measured the level of stress or anxiety one feels about computers. Large values on this scale corresponded to greater anxiety; smaller values to lesser or the absence of anxiety. Upon entering computer courses, the $\bar{x}$ anxiety toward computers was 11.11 but afterwards (at post-test) it had dropped to 10.53. The standard deviations in both instances was larger than 3.25. This indicates a fairly large amount of variation in responses as was typical of all the attitude measures. These data show that despite wide variation in computer anxiety, students felt less anxious about computers by the end of their exposure to courses with instructional computing.

## Computer Self-efficacy

If a person feels confident about his/her ability to deal with computers, then we call him/her computer self-efficacious. Another five item scale assessed this attitudinal variable. The average level was 16.52 at pretest and 17.24 at post-test. Again, there was a gain in the positive direction associated with exposure to computer classes. Even after such exposure the level of confidence in one's own ability with computers (computer self-efficacy) was less than the expressed attitude toward computers (computer enjoyment).

Computer Sex-typing

Five items were included to the extent to which students stereotyped computing and computers as a male domain. Very high values on this scale indicate acceptance of the stereotype; very low values indicate rejection of the "computers are more for boys/men" sex-typing. At pretest the average score was 10.44, which dropped to 10.04 by post-test. Thus the computer course experience overall had the effect of reducing the sterotyping of computers as more for males than for females.

Policy Concern

This attitudinal variable was designed to measure the extent to which a person feels concern about the social policy issues such as privacy and security which are raised by the use of computers. The pretest average of this five item scale was 18.42, the post-test 18.86. These levels demonstrated that the students felt considerable concern and that this had become a matter of even greater concern by the end of computer courses.

Educational Computer Support

Another social attitude measured was the degree to which one feels positive toward the inclusion of computers and computer courses in education. The pretest average of 19.09 and post-test average of 19.77

indicated strong expressed support for educational computing on the part of the students.

Social Value Orientation

Each student rated a list of values on three point scales:

1) unimportant
2) important
3) extremely important

The social value orientation was constructed as the sum of the ratings on these five personal and social values: freedom, world peace, love and friendship, and self-respect. The possible range in values was 5 to 15 and the student average at pretest was 13.82 and at post-test was 13.93. Apparently most students rated all the values in this set as "extremely important."

Technical Value Orientation

Another value measure was created by combining the ratings of the four technical values: economic growth, scientific knowledge, technological advancement, and efficiency. The value orientation score potential range was from 4 to 12. The pretest average was 11.28 and the post-test 11.49. Again the values in this cluster were generally rated as extremely important.

Composite Cognitive Computer Literacy

Because of the diversity in attitudinal scales, no attempt was made to construct an attitudinal composite score for affective computer literacy. A cognitive composite was constructed however, to represent an estimate of the students' overall computer knowledge. All 49 cognitive test items were combined in terms of the total number of correct answers. The composite scores ranged from 0 to 49, and as shown in our technical report on test validation (Appendix F), the scores were normally distributed between the two extremes. At pretest the average percent correct on the composite was 49 and at post-test the average had risen to 57. (See Figure 7) Table 16 gives not only the average composite scores for junior and senior high separately, but also gives the means and standard deviations for both pretest and post-test for every class. On the average a senior high student got eight more questions correct than a junior high student. (See Table 16) It is quite evident from scanning Table 16 that there was substantial variation among classes with respect to composite scores. Even within a single type of course considerable differences occurred with respect to composite scores both before and after the computer experience took place. But in almost all classes the composite level of computer knowledge went up from pre- to post-test.

The Impact of Different Types of Instructional Computing Courses

A major purpose of the field study was to attempt to measure the relative contributions of typical instructional computing activities in secondary schools to the development of computer literacy. As described in a previous section, computer courses were categorized to represent unique yet common approaches to instructional computing and the development of computer literacy.

Table 17 reports the pre- and post-instruction means and standard deviations by type of course (CAI, Programming, Computer Appreciation, Computer Studies and "Control") for the cognitive subtests: Hardware, Programming and Algorithms, Software and Data Processing, Applications, Impact, and the composite test. The attitude scores for the Enjoyment, Anxiety, Efficacy, Sex-typing, Policy Concern, Educational Computer Support, Value 1 (Social) and Value 2 (Technical) scales are presented in Table 18.

Table 16

JUNIOR HIGH CLASSES

| | Class | | | | Composite Scores | | | |
|---|---|---|---|---|---|---|---|---|
| | No. | Name | Grade | N | Pretest | | Post-Test | |
| | | | | | $\bar{X}$ | SD | $\bar{X}$ | SD |
| CAI | 5269 | Mathematics | 7 | 22 | 19.1 | 5.3 | 22.0 | 7.9 |
| | 7420 | Mathematics (SLBP) | 7-9 | 12 | 18.4 | 2.4 | 19.5 | 6.7 |
| | 3257 | Mathematics (Title I) | 7-9 | 15 | 12.4 | 4.4 | 16.8 | 7.7 |
| | 0784 | Physical Science | 9 | 19 | 17.2 | 5.6 | 20.1 | 8.6 |
| | 7455 | Social Studies | 8 | 37 | 27.4 | 6.9 | 31.5 | 7.4 |
| | | TOTAL | | 104 | 20.6 | 7.8 | 24.9 | 8.5 |
| COMPUTER APPRECIATION | 2043 | Mathematics | 7 | 18 | 16.0 | 6.9 | 18.3 | 6.7 |
| | 0837 | Mathematics | 8 | 28 | 23.3 | 6.6 | 25.9 | 7.5 |
| | | TOTAL | | 46 | 20.5 | 7.6 | 22.8 | 8.1 |
| PROGRAMMING | 3969 | Algebra I | 8 | 12 | 31.7 | 4.6 | 37.3 | 4.3 |
| | 6528 | Algebra I | 9 | 15 | 27.5 | 6.2 | 27.3 | 5.6 |
| | 7590 | Algebra I | 9 | 16 | 23.8 | 6.5 | 28.3 | 7.3 |
| | 7759 | Basic Computer | 8 | 27 | 20.4 | 7.0 | 25.1 | 6.8 |
| | 0377 | Computer Insights | 9 | 11 | 25.1 | 6.3 | 28.9 | 7.3 |
| | 0078 | Computer Programming | 7 | 29 | 19.7 | 5.5 | 23.9 | 6.8 |
| | 5592 | Mathematics | 7 | 29 | 21.8 | 6.1 | 29.5 | 7.4 |
| | 4393 | Mathematics | 7 | 24 | 18.8 | 6.2 | 24.8 | 5.7 |
| | 3578 | Mathematics | 8 | 20 | 23.4 | 6.7 | 33.5 | 6.7 |
| | 6217 | Mathemaitcs | 9 | 18 | 12.8 | 6.7 | 11.9 | 5.2 |
| | | TOTAL | | 207 | 21.4 | 7.7 | 26.2 | 8.9 |
| COMPUTER STUDIES | 3843 | Computer Science | 8 | 12 | 22.5 | 8.3 | 28.2 | 8.2 |
| | 5255 | Into. to Computers | 8 | 20 | 19.3 | 6.0 | 31.8 | 5.5 |
| | 0501 | Mathematics | 7 | 24 | 18.0 | 7.0 | 26.7 | 5.7 |
| | 1620 | Mathematics | 8 | 113[1] | 20.0 | 7.7 | 25.9 | 7.4 |
| | | TOTAL | | 169 | 19.7 | 7.4 | 26.9 | 7.2 |
| CONTROL | 4245 | Mathematics | 7 | 27 | 16.0 | 6.2 | 14.2 | 6.7 |
| | 8232 | Mathematics | 8 | 52[2] | 22.5 | 6.8 | 24.6 | 6.5 |
| | 0002 | Mathematics | 8 | 20 | 19.1 | 5.8 | 21.6 | 5.9 |
| | 0004 | Mathematics | 8 | 24 | 20.2 | 7.0 | 23.7 | 7.6 |
| | | TOTAL | | 123 | 28.1 | 6.9 | 21.7 | 7.7 |
| | | JUNIOR HIGH TOTAL | | 649 | 20.5 | 7.4 | 24.9 | 8.5 |

1 Five similar classes taught by the same tacher.
2 Two similar classes taught by the same teacher.

Table 16 (cont)

SENIOR HIGH CLASSES

| | Class No. | Class Name | Grade | N | Pretest $\bar{X}$ | Pretest SD | Post-Test $\bar{X}$ | Post-Test SD |
|---|---|---|---|---|---|---|---|---|
| CAI | 6428 | Biology | 10-11 | 22 | 23.4 | 6.4 | 24.4 | 6.5 |
| | 4666 | Hyman Ecology | 10-12 | 19 | 23.5 | 8.0 | 26.3 | 7.4 |
| | 2434 | Physics | 11-12 | 5 | 38.4 | 1.1 | 41.6 | 1.1 |
| | 0464 | Physics | 12 | 21 | 24.8 | 8.0 | 27.5 | 6.7 |
| | 6375 | Physics | 12 | 33 | 34.4 | 6.6 | 34.4 | 9.0 |
| | | TOTAL | | 101 | 28.4 | 8.8 | 29.5 | 8.9 |
| COMPUTER APPRECIATION | 5741 | Advanced Bookkeeping | 11-12 | 14 | 25.4 | 7.6 | 29.6 | 7.0 |
| | 1486 | Clerical Office Prac. | 11-12 | 17 | 28.8 | 6.3 | 28.3 | 8.6 |
| | 2733 | Office Education | 11-12 | 19 | 27.5 | 6.6 | 29.6 | 5.9 |
| | | TOTAL | | 50 | 27.4 | 6.8 | 29.2 | 7.1 |
| PROGRAMMING | 5642 | Advanced Algebra | 10-12 | 27 | 29.8 | 6.3 | 35.1 | 4.9 |
| | 5011 | Advanced Mathematics | 12 | 16 | 38.7 | 3.5 | 38.6 | 6.0 |
| | 6191 | Advanced Mathematics | 11-12 | 13 | 32.8 | 6.7 | 37.7 | 4.7 |
| | 4358 | Beginning Basic | 10-12 | 8 | 26.2 | 9.9 | 34.9 | 7.1 |
| | 4927 | Computer Programming | 10-12 | 33 | 29.5 | 10.0 | 35.8 | 9.6 |
| | 2576 | Computer Science | 10-12 | 14 | 26.1 | 9.2 | 36.4 | 5.2 |
| | 5454 | Geometry | 10 | 19 | 29.3 | 4.8 | 33.3 | 5.3 |
| | 0999 | Geometry | 10 | 19 | 28.8 | 9.0 | 36.6 | 8.5 |
| | 5783 | Probability & Stat. | 12 | 22 | 36.7 | 5.8 | 40.5 | 4.4 |
| | | TOTAL | | 171 | 31.1 | 8.3 | 36.5 | 6.9 |
| COMPUTER STUDIES | 7230 | Basic Computer Prog. | 10-12 | 12 | 29.7 | 5.3 | 32.7 | 3.9 |
| | 0968 | Computer Science | 10-12 | 6 | 27.5 | 9.3 | 31.3 | 9.0 |
| | 6767 | Computer Science | 11-12 | 16 | 24.7 | 9.5 | 33.3 | 9.9 |
| | 7617 | Computer Programming | 10-12 | 17 | 29.7 | 9.0 | 34.8 | 6.8 |
| | 0719 | Data Processing | 11-12 | 20 | 26.4 | 9.2 | 34.3 | 8.0 |
| | 4056 | Into. to the Computer | 10-12 | 10 | 15.8 | 7.0 | 25.5 | 9.9 |
| | | TOTAL | | 81 | 26.0 | 9.3 | 32.7 | 8.3 |
| CONTROL | 7994 | Biology | 10 | 23 | 24.8 | 7.0 | 24.5 | 8.0 |
| | 0003 | Intermed. Alg. & Trig. | 11 | 18 | 30.5 | 4.6 | 31.8 | 4.7 |
| | 0001 | Recordkeeping | 11 | 13 | 18.2 | 5.7 | 18.8 | 5.7 |
| | | TOTAL | | 54 | 25.1 | 7.5 | 25.6 | 8.1 |
| | | SENIOR HIGH TOTAL | | 457 | 28.4 | 8.6 | 32.2 | 8.7 |
| | | GRAND TOTAL | | 1106 | 23.7 | 8.9 | 27.9 | 9.3 |

Table 17

COMPUTER LITERACY QUESTIONNAIRE PART II, COGNITIVE TESTS

| Test | | CAI (N=205) Pre | CAI Post | Programming (N=378) Pre | Programming Post | Computer Appreciation (N=96) Pre | Computer Appreciation Post | Computer Studies (N=250) Pre | Computer Studies Post | "Control" (N=177) Pre | "Control" Post | Combined (N=1106) Pre | Combined Post |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardware (8 items) | $\bar{x}$ | 3.24 | 3.80 | 3.65 | 4.44 | 3.40 | 3.60 | 3.18 | 4.84 | 3.24 | 3.24 | 3.38 | 4.15 |
| | s.d. | 1.84 | 1.78 | 1.76 | 1.81 | 1.62 | 1.74 | 1.68 | 1.56 | 1.45 | 1.53 | 1.71 | 1.79 |
| Prog/Algorithms[a] (5 items) | $\bar{x}$ | 0.64 | 0.99 | 0.83 | 1.90 | 0.51 | 0.53 | 0.44 | 1.12 | 0.36 | 0.47 | 0.60 | 1.21 |
| | s.d. | 0.93 | 1.12 | 1.04 | 1.27 | 0.71 | 0.63 | 0.65 | 1.10 | 0.56 | 0.55 | 0.87 | 1.20 |
| Software & DP (8 items) | $\bar{x}$ | 3.92 | 4.51 | 4.56 | 5.66 | 4.03 | 4.67 | 3.56 | 5.08 | 3.62 | 3.89 | 4.02 | 4.94 |
| | s.d. | 2.48 | 2.42 | 2.16 | 2.23 | 2.14 | 2.04 | 1.93 | 2.14 | 1.92 | 2.08 | 2.18 | 2.29 |
| Applications (15 items) | $\bar{x}$ | 8.79 | 9.32 | 8.96 | 9.96 | 8.54 | 8.98 | 7.85 | 9.41 | 7.90 | 8.10 | 8.47 | 9.33 |
| | s.d. | 3.02 | 3.01 | 3.24 | 3.10 | 2.78 | 2.91 | 3.15 | 2.79 | 2.69 | 2.82 | 3.09 | 3.01 |
| Impact (13 items) | $\bar{x}$ | 7.70 | 8.16 | 7.77 | 8.90 | 7.58 | 8.41 | 6.74 | 8.34 | 6.51 | 7.15 | 7.31 | 8.31 |
| | s.d. | 2.91 | 3.09 | 2.87 | 2.83 | 2.58 | 2.72 | 2.86 | 2.67 | 2.68 | 2.91 | 2.87 | 2.90 |
| Composite (49 items) | $\bar{x}$ | 24.30 | 26.78 | 25.76 | 30.86 | 24.06 | 26.19 | 21.78 | 28.78 | 21.62 | 22.86 | 23.78 | 27.95 |
| | s.d. | 9.06 | 9.56 | 9.31 | 9.57 | 7.95 | 8.17 | 8.58 | 8.05 | 7.49 | 8.06 | 8.87 | 9.30 |

[a] The 3 programming items at the end of the Composite Test were optional and were attempted by about 30 percent of the subjects.

The test scores were first analyzed to determine whether or not learning occurred; e.g., was the change from pre- to post-test significantly different from zero? Table 19 contains a summary of the _t_-tests on gain scores for combined junior and senior high school students.

First examining only the cognitive area comparisons, we found 25 of the 30 _t_-tests to be statistically significant ($p \leq 0.05$). These were distributed across all types of courses but the majority occurred in conjunction with CAI, Programming, and Computer Studies where all 18 _t_-tests were significant.

Table 19 also contains a summary of the _t_-tests on the gain scores associated with the attitude scales. The results indicate significant ($p \leq 0.05$) gains in 19 of 40 _t_-test comparisons with the majority of these (13) occurring in the Programming and Computer Studies type of

Table 18

COMPUTER LITERACY QUESTIONNAIRE PART I,
ATTITUDE SCALES

Course Type

| Scale[a] | | CAI (N=205) Pre | CAI Post | Programming (N=378) Pre | Programming Post | Computer Appreciation (N=96) Pre | Computer Appreciation Post | Computer Studies (N=250) Pre | Computer Studies Post | "Control" (N=177) Pre | "Control" Post | Combined (N=1106) Pre | Combined Post |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Enjoyment | $\bar{x}$ | 18.15 | 18.99 | 18.70 | 18.72 | 17.69 | 17.88 | 19.11 | 19.83 | 16.66 | 17.47 | 18.30 | 18.76 |
| | s.d. | 3.63 | 3.96 | 3.89 | 4.42 | 3.42 | 3.88 | 3.00 | 3.78 | 3.45 | 3.70 | 3.63 | 4.11 |
| | N | 185 | | 366 | | 90 | | 241 | | 161 | | 1043 | |
| Anxiety[c] | $\bar{x}$ | 11.14 | 11.18 | 10.72 | 10.24 | 12.29 | 11.68 | 11.22 | 9.91 | 11.75 | 11.52 | 11.21 | 10.66 |
| | s.d. | 3.21 | 3.59 | 3.35 | 3.44 | 3.14 | 3.12 | 3.34 | 3.36 | 3.06 | 3.27 | 3.29 | 3.46 |
| | N | 194 | | 361 | | 93 | | 240 | | 162 | | [illegible] | |
| Efficacy | $\bar{x}$ | 16.32 | 16.70 | 16.74 | 17.42 | 15.76 | 16.41 | 16.57 | 17.66 | 15.75 | 16.39 | 16.38 | 17.09 |
| | s.d. | 3.23 | 3.33 | 2.98 | 3.53 | 3.02 | 2.96 | 2.95 | 3.64 | 2.93 | 3.05 | 3.04 | 3.43 |
| | N | 195 | | 362 | | 94 | | 244 | | 167 | | 1062 | |
| Sex-typing[c] | $\bar{x}$ | 10.99 | 10.77 | 9.92 | 9.44 | 10.29 | 10.07 | 10.84 | 10.27 | 10.2[illegible] | 10.40 | 10.42 | 10.08 |
| | s.d. | 3.34 | 3.36 | 3.27 | 3.16 | 3.30 | 3.29 | 2.87 | 3.26 | 3.08 | 3.35 | 3.19 | 3.29 |
| | N | 196 | | 365 | | 96 | | 241 | | 173 | | 1071 | |
| Policy Concern | $\bar{x}$ | 18.34 | 18.61 | 18.45 | 18.84 | 18.65 | 18.80 | 18.34 | 19.13 | 18.22 | 18.27 | 18.39 | 18.77 |
| | s.d. | 3.13 | 3.11 | 2.84 | 3.34 | 2.82 | 2.83 | 2.97 | 3.16 | 2.94 | 3.39 | 2.94 | 3.23 |
| | N | 197 | | 363 | | 95 | | 239 | | 171 | | 1065 | |
| Educational Computer Support | $\bar{x}$ | 18.95 | 19.32 | 19.30 | 20.12 | 19.20 | 19.36 | 18.87 | 19.73 | 18.12 | 18.48 | 18.94 | 19.56 |
| | s.d. | 2.59 | 3.11 | 2.85 | 3.08 | 2.23 | 2.35 | 2.54 | 2.98 | 2.71 | 2.89 | 2.69 | 3.02 |
| | N | 193 | | 366 | | 94 | | 246 | | 170 | | 1069 | |
| Value 1 (Social) | $\bar{x}$ | 13.92 | 13.95 | 13.78 | 13.87 | 13.91 | 14.17 | 13.80 | 13.93 | 13.54 | 13.56 | 13.78 | 13.87 |
| | s.d. | 1.29 | 1.37 | 1.55 | 1.44 | 1.32 | 1.22 | 1.31 | 1.52 | 1.54 | 1.63 | 1.43 | 1.47 |
| | N | 201 | | 362 | | 93 | | 248 | | 173 | | 1077 | |
| Value 2 (Technical) | $\bar{x}$ | 11.23 | 11.24 | 11.24 | 11.53 | 11.41 | 11.53 | 11.34 | 11.61 | 10.83 | 11.08 | 11.21 | 11.42 |
| | s.d. | 1.79 | 1.94 | 1.82 | 2.01 | 1.82 | 1.82 | 1.99 | 1.88 | 1.82 | 1.96 | 1.86 | 1.95 |
| | N | 201 | | 368 | | 93 | | 243 | | 172 | | 1077 | |

a. All scales have 5 items except for Value 2 which has 4. See Technical Report for a description of the scoring procedure.
b. Incomplete data resulted in different N's for the various scales. Number of missing cases can be obtained by subtracting the row entry from the N indicated with each column heading.
c. Negative gain means less anxious (lower sex stereotyping).

courses. At the level of the total sample, the gains are significant for all of the eight attitude scales (see bottom row of Table 19).

Following this analysis, the gain scores were subjected to analyses of variance contrasts to determine the relative impact of the various types of courses. The statistical procedure included one way analyses of variance (ANOVA's) on the gain scores, with the type by courses as the experimental or independent variable. In addition to ANOVA, all gain scores were analyzed using the STUDENT-NEWMAN-KEULS (SNK) procedure - a somewhat conservative procedure for making all pairwise comparisons

Table 19

SUMMARY OF t-TESTS ON GAIN SCORES, PRE-POST[a]

| Course Type | Attitude Scales[b] (Part 1) | | | | | | | | Cognitive Tests and Composite[c] (Part II) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ENJ | ANX | EFF | SEXR | POL | EDUC | V1 | V2 | H | P | S | A | L | COM |
| Computer Assisted Instruction (CAI) | X | | | | | | | | X | X | X | X | X | X |
| Programming (PR) | | X[d] | X | X[e] | X | X | | X | X | X | X | X | X | X |
| Computer Appreciation (CA) | | X[d] | X | | | | X | | | X | | | X | X |
| Computer Studies (CS) | X | X[d] | X | X[e] | X | X | | X | X | X | X | X | X | X |
| "Control" (C) | X | | X | | | | | | | X | X | | X | X |
| Combined | X | X[d] | X | X[e] | X | X | X | X | X | X | X | X | X | X |

a. The check mark (X) entry indicates that the gain was significantly different from zero with $p \leq 0.05$ and in all cases are positive gains except where noted.
b. The codes are ENJ-Enjoyment, ANX-Anxiety, EFF-Efficacy, SEXR-Sex-typing, POL-Policy Concern, EDUC-Educational Computor Support, V1-Values 1 (Social), V2-Values 2 (Technical).
c. The codes are H-Hardware, P-Programming and Algorithms, S-Software and Data Processing, A-Applications, I-Impact, and COM-Composite.
d. Negative gain, hence less anxious.
e. Negative gain, hence less sex role stereotyping.

among all categories when the cells are of unequal sizes. Tables 20 to 24 report the results of this analysis on the cognitive subtests and Table 25 reports the composite test results. All the ANOVA's were statistically significant and the SNK results were generally consistent across the cognitive subtests with Computer Studies and Programming producing more gains in computer knowledge scores than CAI, Computer Appreciation and "Control." Except for the Programming and Algorithms subtest, the Computer Studies approach demonstrated higher gains than the other approaches or types of computer courses. The category of courses titled Programming was significantly higher than all other course types on the Programming and Algorithms subtest as is to be expected. (See Table 21)

If one contrasts the relative gains for alternative types of computer classes using the overall, composite score (Table 25), the conclusion is

Table 20

GAIN SCORE ANALYSIS OF HARDWARE TEST (8 items)
BY COURSE TYPE

| Course Type[a] | $\bar{x}$ | s.d. | N |
|---|---|---|---|
| Computer Assisted Instruction (CAI) | .55 | 1.70 | 205 |
| Programming (PR) | .80 | 1.60 | 378 |
| Computer Appreciation (CA) | .21 | 1.63 | 96 |
| Computer Studies (CS) | 1.66 | 1.77 | 250 |
| "Control" (C) | .01 | 1.42 | 177 |
| TOTAL | .77 | | 1106 |

ANOVA

| Source | df | Sum of Squares | Mean Square | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 340.0696 | 85.0174 | 31.7876 | .0000 |
| Within Groups | 1101 | 2944.6755 | 2.6745 | | |
| TOTAL | 1105 | 3284.7450 | | | |

STUDENT-NEWMAN-KEULS Procedure

Ranges for 0.05 level[b]: 2.81, 3.33, 3.65, 3.87

Homogeneous Subsets[c]:

Subset 1

| | | |
|---|---|---|
| Group | C | CA |
| Mean | .01 | .21 |

Subset 2

| | | |
|---|---|---|
| Group | CA | CAI |
| Mean | .21 | .55 |

Subset 3

| | | |
|---|---|---|
| Group | CAI | PR |
| Mean | .55 | .80 |

Subset 4

| | |
|---|---|
| Group | CS |
| Mean | 1.66 |

a. means and s.d.'s are rounded to hundredths.
b. The ranges are tabular values. The value actually compared with Mean(J)-Mean(I) is 1.7201*Range*Sqrt(1/N(I)+1/N(J)).
c. The means of the first and last groups differ by less than the critical value for a subset of that size.

Table 21

GAIN SCORE ANALYSIS OF PROGRAMMING AND ALGORITHMS TEST (5 items) BY COURSE TYPE

| Course Type[a] | $\bar{x}$ | s.d. | N |
|---|---|---|---|
| Computer Assisted Instruction (CAI) | .35 | .90 | 205 |
| Programming (PR) | 1.07 | 1.29 | 378 |
| Computer Appreciation (CA) | .02 | .71 | 96 |
| Computer Studies (CS) | .68 | 1.05 | 250 |
| "Control" (C) | .11 | .66 | 177 |
| TOTAL | .60 | | 1106 |

ANOVA

| Source | df | Sum of Squares | Mean Square | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 173.7524 | 43.4381 | 39.8947 | .0000 |
| Within Groups | 1101 | 1198.7901 | 1.0888 | | |
| TOTAL | 1105 | 1372.5425 | | | |

STUDENT-NEWMAN-KEULS Procedure

Ranges for 0.05 level[b]: 2.81, 3.33, 3.65, 3.87

Homogeneous Subsets[c]:

| | | |
|---|---|---|
| Subset 1 | | |
| Group | CA | C |
| Mean | .02 | .11 |
| Subset 2 | | |
| Group | CAI | |
| Mean | .35 | |
| Subset 3 | | |
| Group | CS | |
| Mean | .68 | |
| Subset 4 | | |
| Group | PR | |
| Mean | 1.07 | |

a. means and s.d.'s are rounded to hundredths.
b. The ranges are tabular values. The value actually compared with Mean(J)-Mean(I) is .7378*Range*Sqrt(1/N(I)+1/N(J)).
c. The means of the first and last groups differ by less than the critical value for a subset of that size.

Table 22

GAIN SCORE ANALYSIS OF SOFTWARE AND DATA PROCESSTING TEST (8 items) BY COURSE TYPE

| Course Type[a] | $\bar{x}$ | s.d. | N |
|---|---|---|---|
| Computer Assisted Instruction (CAI) | .59 | 2.47 | 205 |
| Programming (PR) | 1.09 | 1.98 | 378 |
| Computer Appreciation (CA) | .64 | 2.12 | 96 |
| Computer Studies (CS) | 1.51 | 2.09 | 250 |
| "Control" (C) | .28 | 1.83 | 177 |
| TOTAL | .92 | | 1106 |

ANOVA

| Source | df | Sum of Squares | Mean Square | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 202.1419 | 50.5355 | 11.5447 | .0000 |
| Within Groups | 1101 | 4819.4784 | 4.3774 | | |
| TOTAL | 1105 | 5021.6203 | | | |

STUDENT-NEWMAN-KEULS Procedure

Ranges for 0.05 level[b]: 2.81, 3.33, 3.65, 3.87

Homogeneous Subsets[c]:

Subset 1

| Group | C | CAI | CA |
|---|---|---|---|
| Mean | .28 | .59 | .64 |

Subset 2

| Group | CA | PR |
|---|---|---|
| Mean | .64 | 1.09 |

Subset 3

| Group | CS |
|---|---|
| Mean | 1.51 |

a. means and s.d.'s are rounded to hundredths.

b. The ranges are tabular values. The value actually compared with Mean(J)-Mean(I) is 1.4794*RANGE*Sqrt(1/N(I)+1/N(J)).

c. The means of the first and last groups differ by less than the critical value for a subset of that size.

Table 23

## GAIN SCORE ANALYSIS OF APPLICATIONS TEST (15 items) BY COURSE TYPE

| Course Type[a] | $\bar{x}$ | s.d. | N |
|---|---|---|---|
| Computer Assisted Instruction (CAI) | .53 | 2.75 | 205 |
| Programming (PR) | 1.00 | 2.42 | 378 |
| Computer Appreciation (CA) | .44 | 2.53 | 96 |
| Computer Studies (CS) | 1.56 | 2.56 | 250 |
| "Control" (C) | .20 | 2.38 | 177 |
| TOTAL | .86 | | 1106 |

### ANOVA

| Source | df | Sum of Squares | Mean Square | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 247.1531 | 61.7883 | 9.8744 | .0000 |
| Within Groups | 1101 | 6889.4039 | 6.2574 | | |
| TOTAL | 1105 | 7136.5570 | | | |

### STUDENT-NEWMAN-KEULS Procedure

Ranges for 0.05 level[b]: 2.81, 3.33, 3.65, 3.87

Homogeneous Subsets[c]:

Subset 1

| Group | C | CA | CAI |
|---|---|---|---|
| Mean | .20 | .44 | .53 |

Subset 2

| Group | CA | CAI | PR |
|---|---|---|---|
| Mean | .44 | .53 | 1.00 |

Subset 3

| Group | CS |
|---|---|
| Mean | 1.56 |

a. means and s.d.'s are rounded to hundredths.
b. The ranges are tabular values. The value actually compared with Mean(J)-Mean(I) is 1.7688*RANGE*Sqrt(1/N(I)+1/N(J)).
c. The means of the first and last groups differ by less than the critical value for a subset of that size.

Table 24

GAIN SCORE ANALYSIS OF IMPACT TEST
(13 items) BY COURSE TYPE

| Course Type[a] | $\bar{X}$ | s.d. | N |
|---|---|---|---|
| Computer Assisted Instruction (CAI) | .46 | 2.86 | 205 |
| Programming (PR) | 1.13 | 2.21 | 378 |
| Computer Appreciation (CA) | .82 | 2.05 | 96 |
| Computer Studies (CS) | 1.59 | 2.50 | 250 |
| "Control" (C) | .64 | 2.46 | 177 |
| TOTAL | 1.01 | | 1106 |

ANOVA

| Source | df | Sum of Squares | Mean Square | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 178.6304 | 44.6576 | 7.5465 | .0000 |
| Within Groups | 1101 | 6515.3117 | 5.9176 | | |
| TOTAL | 1105 | 6693.9421 | | | |

STUDENT-NEWMAN-KEULS Procedure

Ranges for 0.05 level[b]: 2.81, 3.33, 3.65, 3.87

Homogeneous Subsets[c]:

Subset 1

| | | | |
|---|---|---|---|
| Group | CAI | C | CA |
| Mean | .46 | .64 | .82 |

Subset 2

| | | | |
|---|---|---|---|
| Group | C | CA | PR |
| Mean | .64 | .82 | 1.13 |

Subset 3

| | |
|---|---|
| Group | CS |
| Mean | 1.59 |

a. Means and s.d.'s are rounded to hundredths.
b. The ranges are tabular values. The value actually compared with Mean(J)-Mean(I) is 1.7201*RANGE*Sqrt(1/N(I)+1/N(J)).
c. The means of the first and last groups differ by less than the critical value for a subset of that size.

Table 25

GAIN SCORE ANALYSIS OF COMPOSITE TEST-COGNITIVE (49 items) BY COURSE TYPE

| Course Type[a] | $\bar{x}$ | s.d. | N |
|---|---|---|---|
| Computer Assisted Instruction (CAI) | 2.48 | 7.20 | 205 |
| Programming (PR) | 5.10 | 6.01 | 378 |
| Computer Appreciation (CA) | 2.13 | 5.12 | 96 |
| Computer Studies (CS) | 7.00 | 6.32 | 250 |
| "Control" (C) | 1.24 | 5.39 | 177 |
| TOTAL | 4.16 | | 1106 |

ANOVA

| Source | df | Sum of Squares | Mean Square | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 4830.7981 | 1207.6995 | 31.8583 | .0000 |
| Within Groups | 1101 | 41737.2525 | 37.9085 | | |
| TOTAL | 1105 | 46568.0506 | | | |

STUDENT-NEWMAN-KEULS Procedure

Ranges for 0.05 level[b]: 2.81, 3.33, 3.65, 3.87

Homogeneous Subsets[c]:

Subset 1

| Group | C | CA | CAI |
|---|---|---|---|
| Mean | 1.24 | 2.13 | 2.48 |

Subset 2

| Group | PR |
|---|---|
| Mean | 5.10 |

Subset 3

| Group | CS |
|---|---|
| Mean | 7.00 |

Summary:
PR > T, CIS, C
M > PR, T, CIS, C

a. means and s.d.'s are rounded to hundredths.
b. The ranges are tabular values. The value actually compared with Mean(J)-Mean(I) is 4.3536*RANGE*Sqrt(1/N(I)+1/N(J)).
c. The means of the first and last groups differ by less than the critical value for a subset of that size.

similar to subtest results. As shown in Table 25, the students in the Computer Studies courses advanced the most, with an average performance gain of 7 points (on the 99 item test), which means that at post-test 7 more items were answered correctly than at pretest. The students in Programming courses gained 5.1 points, which is statistically higher than in the three remaining categories: Computer Appreciation, CAI, and the "Control" group. These three groupings of students gained only about two points on the average.

The attitudinal contrasts among the different types of course approaches is summarized in Table 26 rather than presented in the form of multiple tables. As shown, very few significant differences were found among the affective variable contrasts across the different approaches. Significant contrasts occurred only for the computer anxiety dimension.

With respect to computer anxiety, the Computer Studies courses had significantly greater negative gains than the other types of courses. This means that the students in Computer Studies courses experienced a greater reduction in computer anxiety than students in other types of courses. (See Table 18) The next largest reduction in computer anxiety was found in the Computer Appreciation courses, followed by the Programming courses. Although students in the Computer Appreciation courses showed a greater amount of reduction in computer anxiety than those in the Programming courses, it should be noted that the Programming students started and ended with less computer anxiety--the change just was not as large. This relatively low level of computer anxiety among students in the Programming courses is due mainly to recuitment factors. Students entering both the Programming and the Computer Studies courses tend to have a considerably lower initial, as well as final, level of computer anxiety. Students in CAI courses experienced no change in computer

Table 26

ATTITUDE SCALES MEAN GAINS BY COURSE TYPE:
SUMMARY OF ANOVA AND STUDENT-NEWMAN-KEULS PROCEDURE

| Attitude Scale | ANOVA[a] | | ORDER OF MEANS[b] | STUDENT-NEWMAN-KEULS |
| --- | --- | --- | --- | --- |
| Enjoyment | Combined | .0284 | CAI > C > CS > CA > PR | n.s.d. |
| Anxiety[c] | Combined | .0006 | CS > CA > PR > C > CAI | n.s.d. |
| Sex-typing | [illegible] | n.s.d. | | n.s.d. |
| Policy Concern | Combined | n.s.d. | | n.s.d. |
| Educational Computer Support | Combined | n.s.d. | | n.s.d. |
| Value 1 (Social) | Combined | n.s.d. | | n.s.d. |
| Value 2 (Technical) | Combined | n.s.d. | | n.s.d. |

a. Probability levels are given for F ratios significant at $p \leq 0.05$.
b. Means are ordered for significant ANOVA ($p \leq 0.05$). Note that approaches are designed as CAI-Computer Assisted Instruction, PR-Programming, CA-Computer Appreciation, and C-Control.
c. Note that lower score implies less anxious.

anxiety from pretest to post-test.

## DISCUSSION

Examining all 46 computer classes (courses including some computer use and/or topics) as a whole, we found statistically significant improvement on all the cognitive and affective indicators of computer literacy. Significant improvement also occurred on some of these indicators for students in the "control" classes. This should not be interpreted as simply a matter of learning from testing and retesting. Some students in the "control" classes might well have been concurrently taking computer courses or learning about computers on their own. It is also possible that a teacher given the nature of their recruitment of a "control" class might have unintentially expressed attitudes about computing that influenced students. In light of these potential influences, the affective and cognitive gains for the "control" classes are not of major concern.

Close inspection of the average attitudinal and performance levels on all dimensions by type of computer course (Tables 17-19), as well as the gain score analysis (Tables 20-26), demonstrates that substantially different outcomes are associated with different types of computer experences. Some findings are expected; e.g., the Programming courses produces the greatest gain in the Programming/Algorithms dimension (Table 21). Some findings are more surprising; e.g., the students in courses using CAI made statistically significant improvements on all five cognitive subtests but only one attitude scale, computer enjoyment. Although their knowledge gain was quite modest, it was consistent across all areas, despite the fact that in CAI courses computer literacy is not a major objective, and in most instances, not even a minor objective. The secondary payoff of CAI as a mode of instructional computing is thus evident.

Still unresolved is the question of what underlying factors contribute most to the production of computer literacy. Although we know that certain types of courses, e.g., Computer Studies, yield greater increments in computer literacy than do other types of courses, it is not known from the data presented thus far what it is about these courses that causes these results. Some possible explanations are that these courses simply spend more time on computer topics, or that their access to the computer is better, or that these courses tend to attract better students, or that these courses have better teachers. To begin to explore these questions we asked the teachers to describe their courses by estimating: (1) the number of hours the average student had access to a computer or terminals, (2) the total number of class sessions of the course, and (3) the total number of class sessions devoted to computer topics. The average number of class sessions devoted to computer topics was calculated for each course type and presented in Table 27. A cursory examination of these data reveals considerable variation in course styles, especially when junior and senior high school levels are distinguished. The differences in time on computer topics corresponds roughly to the differences in gain scores among the different course types, as described in the previous section. Thus, it may be that learning gains are merely a function of "time on task." To pursue this further, a multiple regression was performed on the data in which the post-test composite score was predicted from the pretest composite score as well as a series of course related variables (Table 28). To examine the effects of the different types of courses, four dummy variables (x2 to x5) were created to specify the presence or absence of each course type for each student. These course type variables were entered into the regression model first, after which the classroom variables were

Table 27

NUMBER OF CLASS SESSIONS OF EXPOSURE TO COMPUTER TOPICS AS ESTIMATED BY TEACHER FOR ACTIVITY TYPE AND SCHOOL LEVEL*

| | | Junior High | Senior High | Both Junior & Senior High |
|---|---|---|---|---|
| Computer Studies | $\bar{x}$ | 21.7 | 54.8 | 32.5 |
| | SD | 5.6 | 30.4 | 23.6 |
| | N** | 169 | 81 | 250 |
| Programming | $\bar{x}$ | 17.7 | 27.5 | 22.2 |
| | SD | 11.7 | 17.5 | 15.3 |
| | N | 207 | 171 | 378 |
| Computer Appreciation | $\bar{x}$ | 16.6 | 1.4 | 8.7 |
| | SD | 13.3 | 2.3 | 12.0 |
| | N | 46 | 50 | 96 |
| CAI | $\bar{x}$ | 18.6 | 7.4 | 13.1 |
| | SD | 8.8 | 8.1 | 8.85 |
| | N | 104 | 101 | 205 |
| All Groups Combined | $\bar{x}$ | 18.4 | 23.9 | 20.7 |
| | SD | 12.6 | 25.3 | 19.1 |
| | N | 649 | 457 | 1106 |

* Teacher estimates were for the class as a whole, not for each student.

** The "N" is the number of students in each category.

entered into the equation. All of the course type variables had statistically significant contributions to the explained variance which means that they all separately predicted relative gain in composite score knowledge. When the classroom variables, including "hours devoted to computer topics" ($x^b$), were added to the regression equation, the level of contribution of the course type variables, as measured by the magnitude of the B coefficients, was reduced only slightly. This finding means that the differences among the course types cannot all be explained in terms of "time on task," and the accessibility of computer terminals, and the length of the course. If all of the predictive variance in "time on task" had been associated with differences between course types, then variable x7,

Table 28

STEPWISE REGRESSION* PREDICTING POST-TEST COMPUTER LITERACY SCORE FROM PRE-TERM SCORE, APPROACH TYPES, AND CLASS TIME VARIABLES (N = 1,106)

| | | Simple Correlation with Y | B | Standardized B | Cumulative $R^2$ |
|---|---|---|---|---|---|
| X1 | Pre Term Composite Computer Literacy Score | .74 | .75 | .71 | .55 |
| X2 | Computer Assisted Instruction | -.10 | 2.3 | .11** | .56 |
| X3 | Computer Studies | .21 | 6.0 | .26** | .58 |
| X4 | Programming | .20 | 4.4 | .20** | .60 |
| X5 | Computer Appreciation | -.12 | 2.8 | .13** | .60 |
| X6 | No. of Class Sessions on Computer Topics | .22 | .038 | .08** | .61 |
| X7 | No. of Hours Computers/ Terminals Available to Students | .27 | 118 | .05 | .61 |
| X8 | No. of Class Sessions of Course | .23 | -.014 | -.05 | .61 |

*Variables were entered hierarchically as follows: X1 (Pre Text Computer Literacy) was entered first; X2 to X5 (approach types) were entered as a block second; X6 to X8 were entered as a block last.

** $p \leq .001$

the number of hours on computer topics, would not have made a significant contribution to the regression model. The fact that it did indicates that within the different types of computer courses, some of the variation in performance gains can be attributed to variation in time on computer topics. The significant contributions of the course types indicate that the special features of these approaches contribute to learning. Another regression model was investigated but not reported in table form. The same variables were included but a reverse hierarchy was imposed: the classroom variables (x7-x8) were entered first and the course type variables were entered last. The addition of the course type variables produced only minor reductions in the contribution of hours on computer topics, x6. This could indicate that features other than resources and computer topics contribute significantly to the effectiveness of each approach. These other features could be school resources, curriculum, teacher effectiveness, teacher and student attitude, student aptitude, and other student characteristics. Unfortunately, we could not control the recuitment or entry process into these courses, consequently we cannot identify the extent to which the attributes which the students brought with them as they selected these courses affected the outcome of the study. It is our assessment, however, that not all of the variance in the acquisition of computer learning can be explained by such student factors. There is also considerable evidence that instructional strategies and teaching styles make a difference and that these contribute to the relative gains in computer literacy found among different types of courses.

## CONCLUSION

Substantial computer learning occurs in quite different types of instructional computing environments. Our findings document statistically significant gains in both affective and cognitive dimensions of computer literacy.

Although students learn a lot about computers in secondary school computer courses, they often leave these classes without becoming computer literate in the comprehensive sense of the term. The average performance on the final composite cognitive computer literacy test was only 27.9 or

57 percent correct.

Contrasting the major types of computer courses, we found those classified as Computer Studies to produce relatively greater improvements than other course types. Even so, after completing these courses, the average student performance was only 28.8 or 59 percent correct.

Our analysis shows that what the teachers do in the classroom and how much time they devote to computer topics does make a difference on the acquisition of computer literacy. To adequately access the full impact of instructional computing in secondary schools, it is necessary to go beyond the composite measures to examining course objectives and performance on specific dimensions. This analysis has shown that despite considerable heterogeneity in patterns of student knowledge, cognitive computer literacy is rather limited among most secondary students.

CHAPTER 5

# AN EXPERIMENT IN COMPUTER LITERACY AS A CONSEQUENCE OF CAI

Chapter 5

# AN EXPERIMENT IN COMPUTER LITERACY AS A CONSEQUENCE OF CAI

Computers are used with increasing frequency to deliver and enhance instruction in science. The impact of such experiences on students has not yet been extensively investigated. In particular, there is no data on what students learn or do not learn about computers. Several studies have examined the effect of computer use upon attitudes toward computers, but few studies have assessed the impact of computer use upon cognitive computer literacy; i.e., student knowledge about computers. We designed an experiment to investigate the impact of a brief computer assisted instruction (CAI) experience on the attitudes, beliefs, and knowledge of different types of students. A 20-30 minute science unit on water pollution was administered to approximately 350 students by APPLE II micro-computers. Comparison of pretests with post-tests and tests six months later reveal some important impacts of a brief exposure to CAI for science instruction.

## Research on the Impact of CAI

While some prefer to restrict the term CAI to simple "drill and practice" sessions, others use the term more comprehensively to encompass any delivery of instruction by a computer. We accept the broader definition of CAI and it should be noted that the CAI unit developed for this research includes simulation, tutorials, and testing, as well as straight-forward presentation of text. This broad view of CAI is consistent with the definition assumed in most reviews of research on CAI (cf. Thomas, 1979; Edward, et. al., 1975; Jamison, et. al., 1974).

The question pursued in most CAI research is how much gain in achievement results from CAI as compared to other instructional forms. A large share of this research has concentrated on CAI as <u>replacement</u> for traditional teaching. Reviewers of this research have generally concluded that there is no clear evidence that CAI produces greater achievement (Jamison, et. al., 1974; Edwards, et. al., 1975). Furthermore, Kulik, et. al., 1979) did a meta evaluation of research on college level CAI and concluded that course completion rates were slower when CAI replaced traditional instruction.

CAI which is designated to <u>supplement</u> other forms of instruction has generally resulted in significant gains in achievement (Edwards, et. al., 1975; Thomas, 1979). The research on the use of CAI to supplement science teaching has reported significant attitude achievement gains; these studies include a biology program (Broderick, 1974), a physics laboratory simulation (Hughes, 1974) and algebra classes (Morgan and Richardson, 1974). All of these situations involved repeated use of the computer during the course program. None of the investigations examined the effects of a single, brief CAI experience.

The theoretical explanations for the educational productivity of CAI are generally presumed to be (1) motivational improvements, (2) reinforcements due to drill and practice, or (3) improved time utilization. A number of studies have found that students exposed to CAI express increased interest in both the computer and the subject matter (Broderick, 1974; Bukoski and Korotkin, 1975; Grandall, 1976). Other researchers have noted that such attitudinal shifts do not occur when students experience considerable stress resulting from making many errors (Mathis, 1970) or when students have relatively little choice over selection of problems and learning activities (Fisher, et. al., 1974).

This suggests that motivational and performance outcomes are affected by the student's sense of self-efficacy (Hess and Tenezakis, 1970) and anxiety about the learning situation (Sieber, O'Neil, and Tobias, 1977).

Our primary interest was in the learning of content that is incidental to the instructional situation. Specificially, we want to know whether or not students will learn about computers when they are exposed to CAI material totally unrelated to computers; e.g., general science or water pollution. Obviously, some learning can occur at the behavioral level; e.g., the student might not have previously known how to operate a computer terminal. Our concern, however, was with learning in the affective and cognitive domains. If the CAI lesson has an entertaining or autotelic aspect, as suggested by Moore (1980) or comprehensively incorporates systematic instructional design principles, (cf. Ellinger and Brown, 1978), one would expect student affective responses to CAI to be positive. Indeed many studies (e.g., Brown and Gilman, 1969); (Murphy and Appel, 1978) report that students are favorable if not enthusiastic toward CAI after exposure to it. This type of instructional evaluation has not yet been applied to CAI which only involves a single, brief exposure. It is our belief that the situational features of the CAI; e.g., use of multiple modes of communication, interactional styles, and system functioning are important in producing positive affect. These system features may even be more important than the "clock" time of CAI exposure. Consequently, we selected two such features: (1) presence/absence of system failure and (2) presence/absence of enhanced graphics, and built them into our experimental design as controlled factors or treatments. Our prediction was that the presence of enhanced graphics would result in greater gains in positive affective states and that system failure would result in negative affective states.

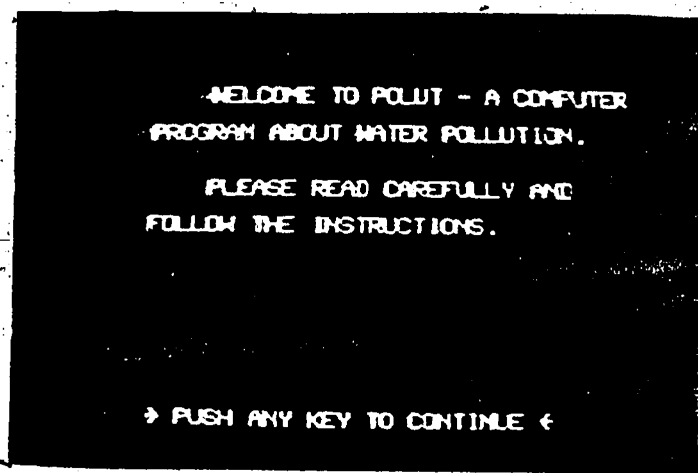
Although previous research has not attempted to determine whether or not CAI produces cognitive computer literacy; i.e., computer knowledge and awareness, it would be reasonable to expect it to occur. One mechanism to produce this effect is the positive affective/motivational state of the student vis-a-vis CAI. This attitude could motivate the student to be more attentive to computers both during computer use and after it as well. Increased attentiveness and purposeful information seeking behavior may well occur as a consequence of increased interest in computers. Motivation for inquiry may be sparked by a situation which yields unresolved questions, unexpected feelings, or new challenges.

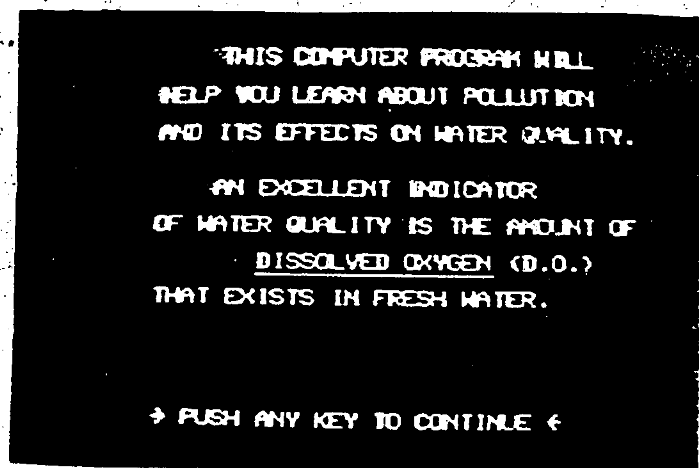
In order to test these hypotheses, a number of affective and cognitive scales and tests were adapted for the computer literacy science learning experiment. These attitudinal and knowledge tests were administered immediately before and immediately after each student spent time with a brief 15-30 minute CAI package. The programmed package is described in the next section.

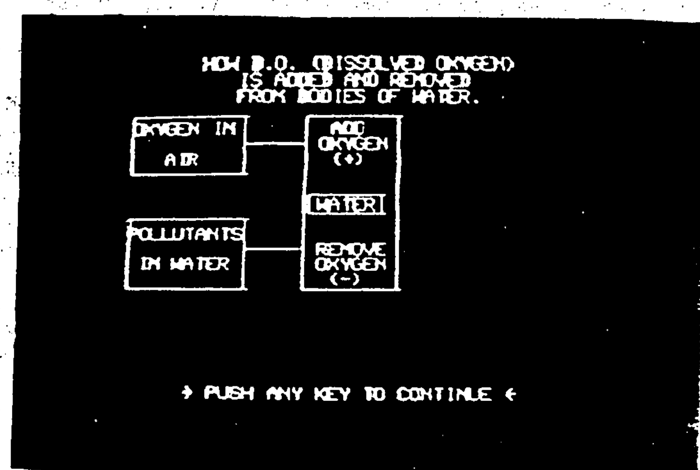
## THE INSTRUCTIONAL PACKAGE ON WATER POLLUTION

Since the research plan was to construct a typical science lesson that could be delivered by the computer, the topic of water pollution was selected and a computer simulation program called POLUT was redesigned to deliver the lesson on an APPLE II microcomputer. POLUT was originally developed as part of the Huntington II project at the State University of New York, Stony Brook, New York. The following major changes were made to the POLUT package: (1) The new package, which we call APOLUT, is totally self-contained in that no written materials are necessary and no instructor intervention is required. (2) The lesson begins by presenting a textual introduction to the water pollution principles underlying the model; three of the first few displays are shown in Frame 1. (3) Following the introduction, a series of four test questions are administered as a "review" of the material on water pollution just presented. (See Frame 2) These four test items, plus six others, were administered as a single competency test after the student completed the unit and had left the computer. (4) The simulation portion of the APOLUT lesson is more restricted and focused than the original POLUT mode. APOLUT contains two specific simulation exercises: one to estimate the maximum water temperature at a given dumping rate before the fish will die (Frame 5), and the other to estimate the maximum dumping rate at a given temperature before the fish will die (Frame 6). The earlier POLUT program allowed several more parameters to be set by the student; furthermore, the student was not given a specific exercise by the computer. (5) While POLUT prints a time series graph, it was not originally designed to take advantage of interactive graphics. APOLUT uses such features as selective erase and animation. Color is also sometimes used to provide contrast. (6) The package is written in APPLESOFT BASIC for the APPLE II computer.

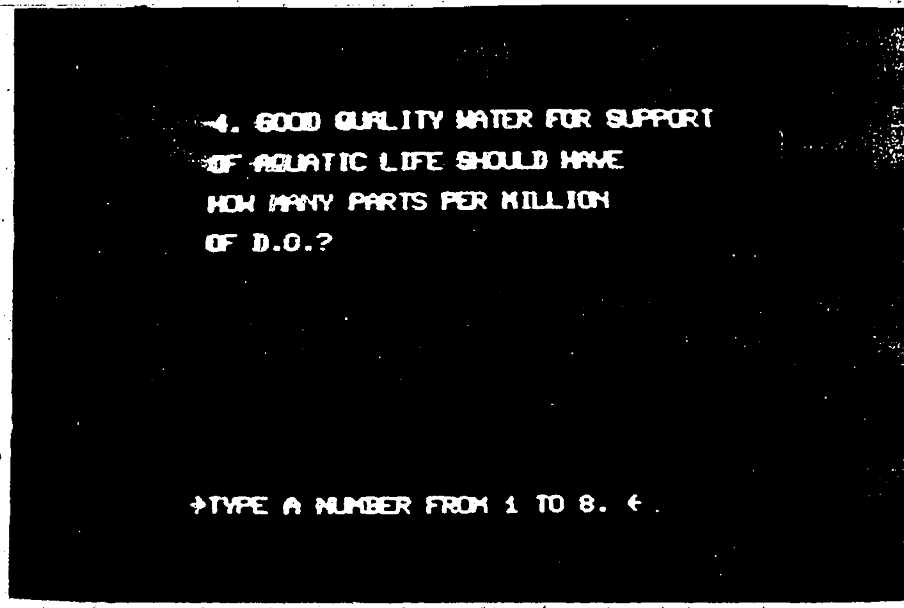
The APOLUT package was written as five separate programs and stored as a linked series on a floppy diskette. The package can be loaded by simply typing the following: 6, ctrl-P, and the RETURN key. Then the program is automatically loaded and begins to produce text for the student. (See Frame 1) At the end of each full screen of text, questions, or graphics, the program waits until the student presses any key. As soon as the key is depressed, the program erases the screen and continues immediately. The RETURN key does not have to be depressed until the last two exercises, at which time the student is told to strike the RETURN key after entering a number. To avoid the possibility that the student might press the RESET key, the APPLE II computer was slightly

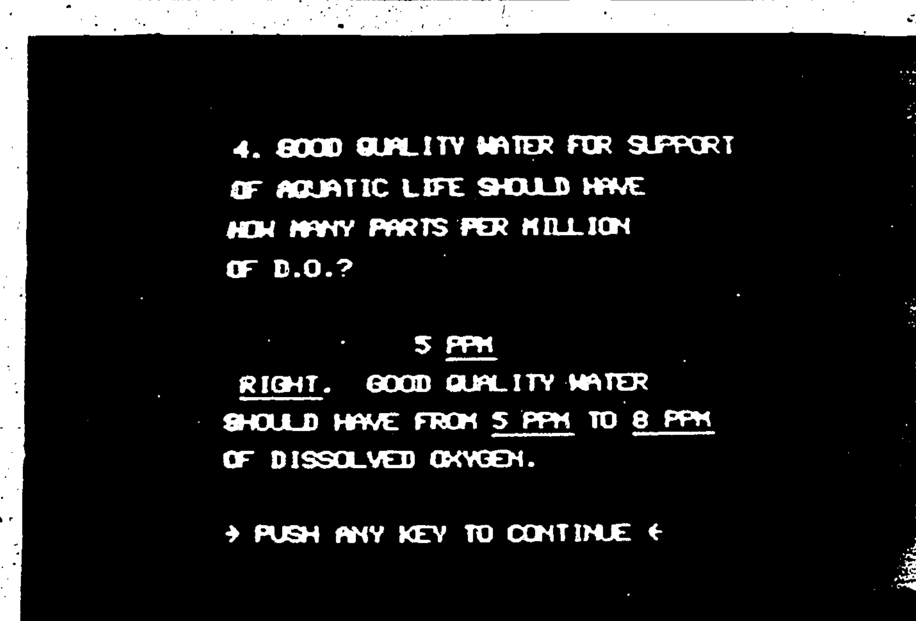


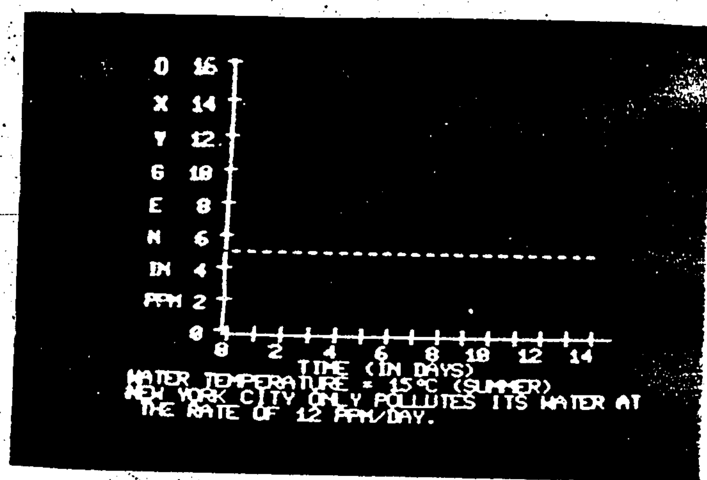



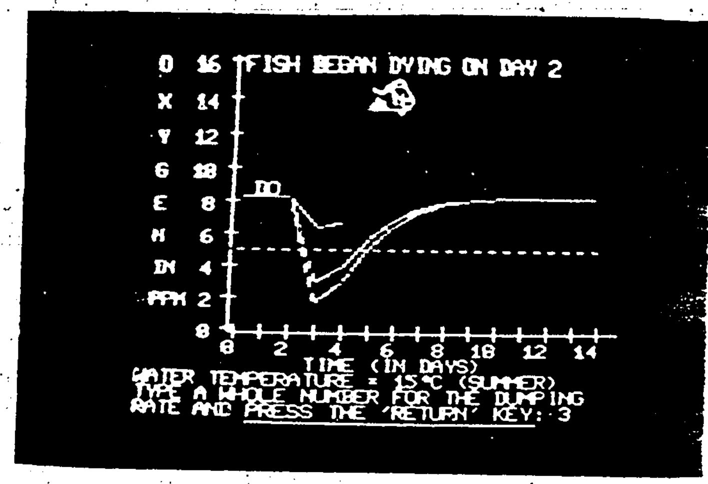

FRAME 1. The first two displays introduce the APOLUT package. The third display appears later but is included here to illustrate the use of line drawings with textual materials.

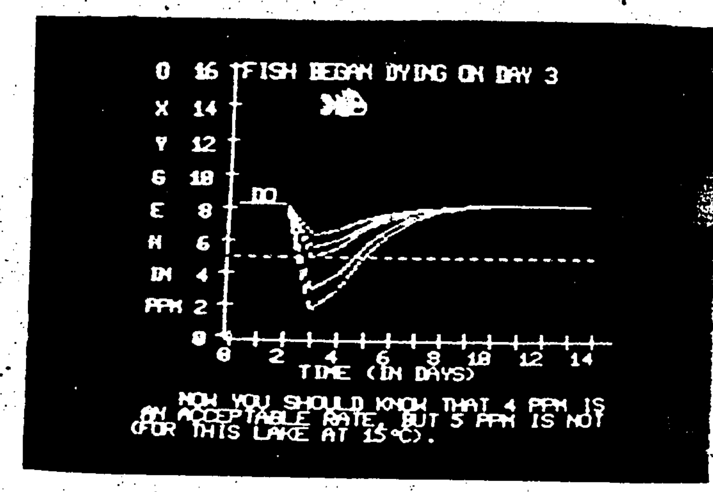


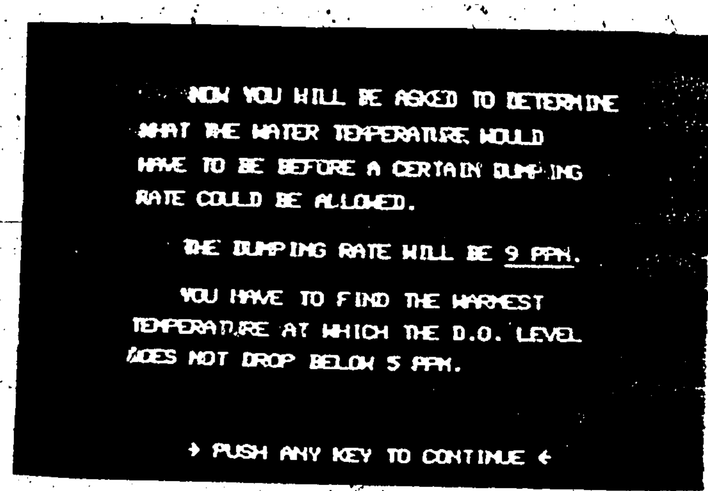

FRAME 2. These two displays illustrate the testing portion of the package. After the question is answered by the student, the student is immediately told whether it is right or wrong. In either case a clarifying comment is also displayed.

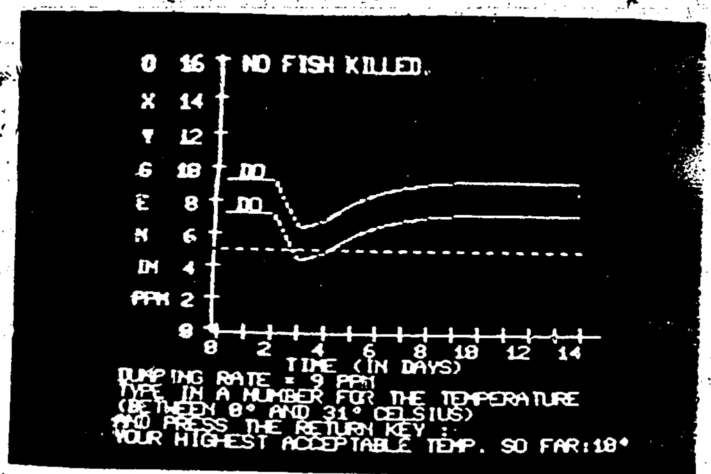


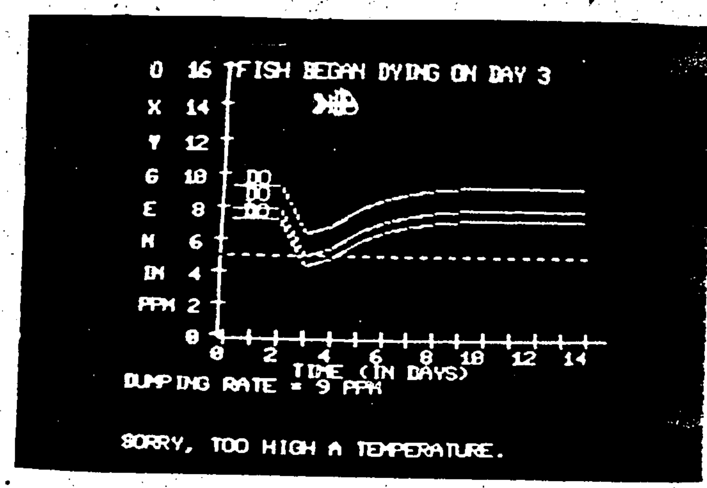




FRAME 5. The first display shows the beginning of the first exercise. The next two displays shows how a student tries to find the correct answer by successive guesses of the appropriate temperature level. The last display shows how the fish, which is swimming across the top of the screen, stops and turns into a skeleton if and when the D.O. level goes below 5.




FRAME 6. This is the second exercise and the student is trying to estimate the largest acceptable dumping rate. Note that in the first display a comment is made about New York City. This was made in response to an unreasonably high dumping rate estimate from the student.

modified. The RESET key was jammed so as to be inoperable for the student; otherwise, the experiment was run on a standard, unmodified APPLE II microcomputer with a single disk, 48K of RAM memory, and a small color TV monitor. The program package is written entirely in high resolution graphics so that text can be accented with underlining and special drawings.

The five programs of the APOLUT package are structured as follows:

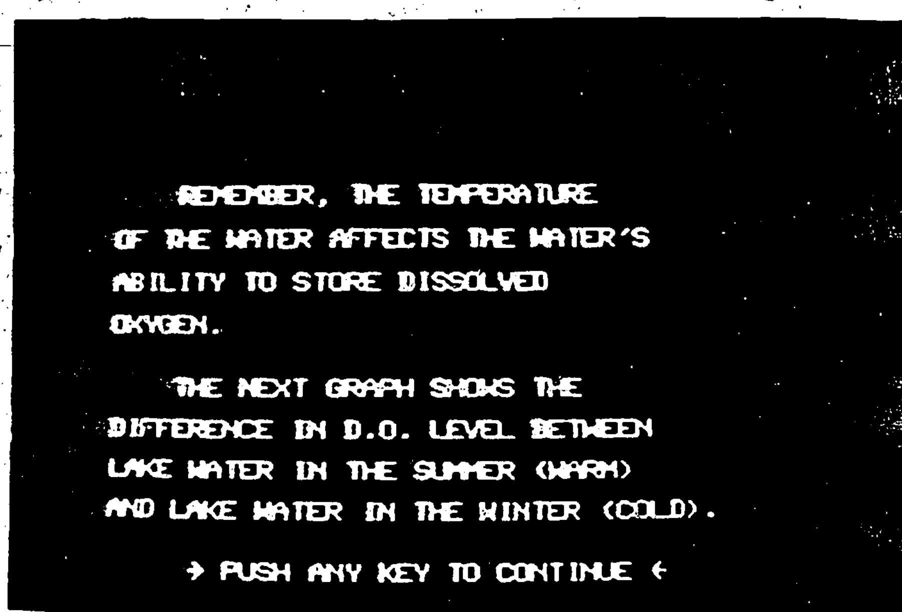
1 - The subject matter is introduced and the essential concepts explained. Some graphical representations are included for clarification. (See Frame 1)

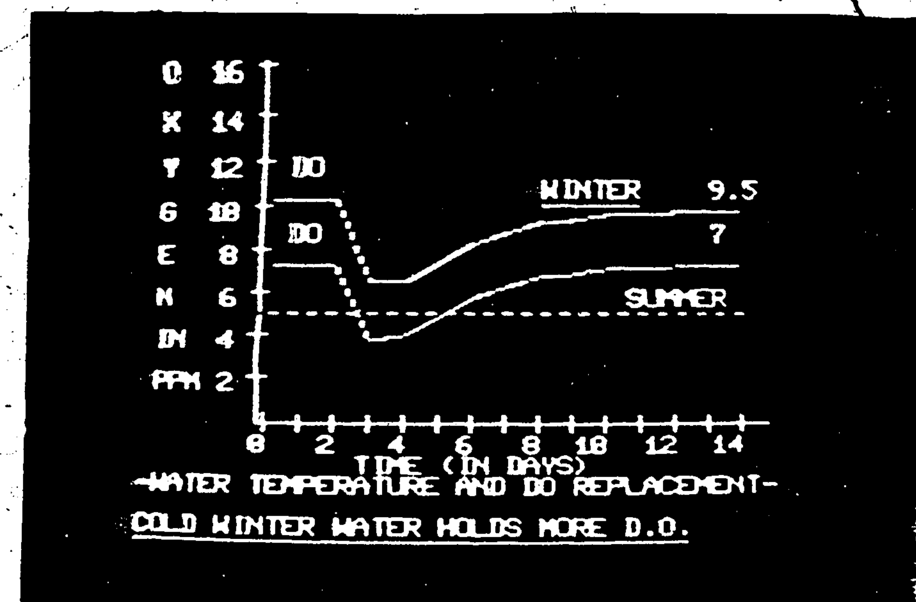
2 - The student is asked four questions based upon the content of program 1. Feedback is given to the student's response with a brief explanation of why the answer was correct or incorrect. (See Frame 2) The responses are recorded by the program for later use.

3 - Graphics are presented to show the dissolved oxygen level of a lake over time, when water temperature and dumping rate are varied. It is expository in that the student does not choose any of the conditions or rates. (See Frames 3 and 4)

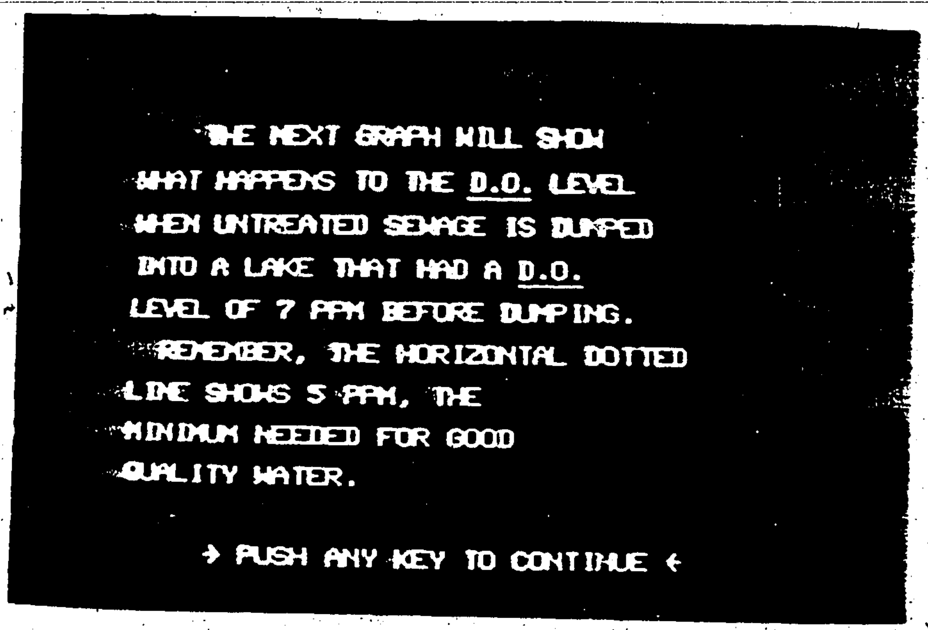
4 - The student is asked to find the largest sewage dumping rate that would avoid the death of fish in a lake. The water temperature is a constant, and successive graphics are produced to illustrate the dissolved oxygen level over time. In the "enhanced display" version of the program, a fish swims across the screen as the graph is being plotted. If the dissolved oxygen level drops below the minimum level, the fish becomes a skeleton and no longer moves. (See Frame 5)

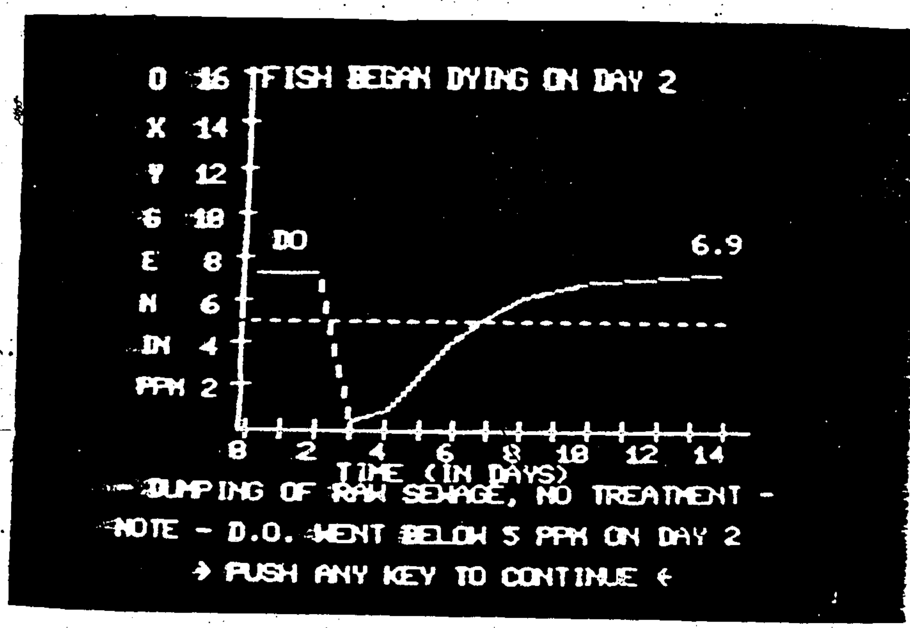
5 - This program is similar to program 4 except that the dumping




FRAME 3. Following the series of test questions, more expository material is presented, but this time with graphs. These displays depict the seasonal impacts over time on Dissolved Oxygen.




FRAME 4. The impact of sewage dumping on dissolved oxygen is simulated here.

rate is held constant while the water temperature is selected by the student. (See Frame 6)

Although the package is broken into five programs, they are chained and appear as one continuous program to the student. The APOLUT unit can be completed in ten minutes although some students took as long as 30 minutes. The average completion time was about 20 minutes.

## METHOD

### Data Collection

The students who served as subjects for this experiment were randomly selected from the ninth and eleventh grades of a single high school. A high school was selected in an urban, nearly suburban, area of the Twin Cities. The site was chosen in part because it contained a broad representation of socio-economic and ethnic groups. The simple random sample of 340 students was taken from a list of all ninth and eleventh grade students. We also hoped to obtain approximately equal numbers of students for each sex and each level of prior exposure to computers. Table 28 demonstrates that this was satisfactorily accomplished.

Table 28

DISTRIBUTIONS ON THE MAJOR COVARIATES: SEX, GRADE, AND COMPUTER EXPOSURE

| Sex | | Grade | | Prior Exposure to Computers | |
|---|---|---|---|---|---|
| Male | 53% | 9th | 49% | Low | 57% |
| Female | 47% | 11th | 51% | High | 43% |
| Total | 100% | Total | 100% | Total | 100% |

The experiment was administered in the school's former computer room. Dividers were placed between the four APPLE II computer systems that were used simultaneously. Students were called out of class four at a time to participate in the study. The entire session, including pre- and post-testing, took less than an hour, thus coinciding with a single class period. A paid laboratory assistant was trained to administer the experiment and supervise the recruitment of students. The administration of this procedure was completed during a two month period in the Spring of 1979.

## The Follow-up Study

Approximately six months later follow-up testing was conducted in the same high school. In October, 1979, the beginning of the next school year, a brief questionnaire was administered to all tenth and twelfth grade students in an attempt to assess the long term effects of the experiment. Several of the questions on the questionnaire asked about earlier participation in the study; from the responses to these questions we were able to determine if they had taken part in the experiment, the remaining students who were not exposed are used as a control group. For reasons of confidentiality, the students were not asked to give their names on either the test used in the experiment or the follow-up test. Consequently, it is not possible to identify long term changes at the individual level. The analysis of the follow-up data is done entirely at the group level.

## Experimental Design

A two by two factorial design was used to introduce two treatments: a planned malfunction and enriched display. Slightly more than 80 subjects were randomly assigned to each of the four cells. The malfunction treatment consisted of a simulated system failure about two-thirds of the way through the lesson. At a predetermined point in the lesson, just after a student had entered a number in response to a question from the computer, the screen was blanked out for two seconds. Random characters were then printed along the bottom and the top of the screen after which the screen blanked out again except for a flashing cursor. At this point the computer would not respond to any entry on the keyboard except a special code which only the laboratory assistant knew. When the student called for assistance from the laboratory assistant, he acted surprised and went over to try to help the student subject. At that point the laboratory assistant said: "I don't know what happened but I think I can get it back to where you left off." The assistant then rapidly typed several keys while looking back and forth from the screen to the keyboard. He eventually entered the special code and the programmed lesson resumed at the point in the lesson where the malfunction occurred. The assistant then asked, "Is this where you left off?" The student responded and then continued with the computer unit.

The enriched display treatment contained three features related to the communicability of the program. The features were: 1) Animation with a little fish swimming across the top of the screen during the simulation of dissolved oxygen change. Whenever the dissolved oxygen went below the danger level, the moving fish stopped and turned into a skeleton. 2) A multicolor mosaic was drawn on the video screen by the computer at the very beginning of the session. The drawing took 30 seconds to complete, and the pollution tutorial began immediately after the drawing was completed. 3) Color was used to differentiate lines in graphs when two lines were displayed simultaneously. This feature was used in two displays about midway through the lesson.

The following indicators were created from the pre- and post-questionnaires.

Prior exposure to computers. An index was created from the following three questions:

1) I have used computers in school. (64 percent answered "yes" to this question.)

2) I have taken a course about computers. (13 percent answered "yes.")

3) I have written computer programs. (47 percent answered "yes.")

A "yes" response to any two of the three questions constituted "high exposure" while all others were considered "low exposure." The pattern of responses to these three questions was tested for unidimensionality and cumulativeness by performing a Guttman scale analysis. An unusually high fit between the model and the data was found; the three questions produced a coefficient or reproductibility of .95 and a coefficient or scalability of .83. As reported in Table 28, there were 43 percent classified as "high exposure." Almost all of these students (93 percent) said they had written computer programs and only 5 percent of those classified as "low exposure" said they had written programs. Thus, self-reported programming experience is the primary criterion of the exposure index. The level of exposure is slightly higher among our subjects than the average Minnesota high school. (A statewide assessment of computer literacy in April, 1979, found 35 percent of all Minnesota 11th grade students claiming to have written computer programs.) Thus the level of exposure in our sample is only slightly higher than the state average and both the experienced and unexperienced are well represented. Almost all prior exposure to computers had been via teletypes to remote time-sharing systems. Two students had previously used the APPLE II system but these students were dropped from our analysis.

## Pollution Test

A ten item test on the content of the APOLUT lesson was constructed for post-test administration. Four of the items were administered via computer as part of the APOLUT package. The test items are a combination of true/false, multiple choice, and completion type. As reported in Table 29, the reliability of the test was .71 at post-testing.

Table 29

RELIABILITY ANALYSIS OF SCALES AND TESTS

| Scale Description | Alpha Reliability Pre Test | Alpha Reliability Post Test | Test-Retest Correlation | No. of Items |
|---|---|---|---|---|
| Pollution Test | --- | .71 | --- | 10 |
| Computer Awareness | .68 | .69 | .82 | 10 |
| Computer Mystique | .62 | .59 | .63 | 4 |
| Computer Enjoyment | .87 | .84 | .76 | 5 |
| Computer Anxiety | .67 | .73 | .64 | 5 |
| Computer Self-Efficacy | .70 | .72 | .70 | 5 |
| Self Esteem | .71 | .75 | .84 | 5 |
| State Anxiety | .74 | .80 | .36 | 5 |
| Locus of Control | .59 | --- | --- | 9 |

## Computer Awareness

Ten items were picked from the Minnesota Computer Literacy Tests (Anderson, et. al., 1979) to determine if learning about computers might occur from a brief exposure to CAI. Items were selected that dealt with elementary concepts or perspectives that could conceivably be affected by a single computer experience. Most of the items are classified as software or social impact in emphasis; however, some are considered applications and hardware items. We call this subtest "awareness" rather than literacy because it does not encompass the comprehensive gamut of topics subsumed under our definition of computer literacy. The computer awareness test had a reliability of .68 and .69 at pretest and post-test respectively (Table 29). The test retest correlation was .82.

Computer Mystique

Four of the ten items in the computer awareness test were treated as a separate test as well. These four items, which are the last four items listed in Table 30, all make statements exaggerating the broad capabilities of computers. The sum of the "true" or incorrect responses to these four items is the scale score. A reliability of approximately .60 was obtained for this measure, which though relatively low is not very low for a test of only four items. The tendency to inaccurately exaggerate the capabilities of computers has been dubbed "computer mystique" in one of our earlier reports (Anderson, et. al., 1979).

Computer Enjoyment

Five items were used from a previously constructed attitude scale to measure general attitude toward computers. Specifically the scale assesses the degree to which persons report they enjoy computers or enjoy learning about computers. The scale reliability is high (.84 and .87) for a scale with only five items. The test retest correlation from pre to post-test was .76.

Table 30

PERCENT CORRECT FOR EACH COMPUTER AWARENESS QUESTION FOR PRE TEST, POST TEST, FOLLOWUP AND CONTROL

| | Pre Test (N=340) | Post Test (N=340) | 6 Mo. Later (N=216) | Control (N=153) |
|---|---|---|---|---|
| 1. Use of computers in education always results in less personal treatment of students. True, (False)*, Don't Know | 37% | 43% | 40% | 35% |
| 2. Using computers can free one to do more creative tasks, but this may lead to more dependence upon machines. (True), False), Don't Know | 72% | 67% | 75% | 75% |
| 3. Computers are not good for tasks that require: speed, accuracy, (intuition), repetion. True, False, (Don't Know) | 67% | 68% | 77% | 68% |
| 4. When in operation, a computer: (Follows a set of instructions written by people), Thinks just like a person, Recalls answers from memory, Translates data from digital to analog code, Don't Know | 57% | 48% | 67% | 57% |
| 5. If your charge account bill has an error, it was probably caused by: Breakdown of the computer, (Mistakes made by people), Poor design of the computer, General weaknesses of machines, Don't Know | 54% | 57% | 63% | 50% |
| 6. The computer must have two types of information to solve a problem: The problem and the answer, The name of the program and user number, (The data and the instructions), The name of the program and your name, Don't Know | 50% | 57% | 62% | 57% |
| 7. Computers help people make decisions by providing correct answers to any questions: True, (False), Don't Know | 29% | 33% | 44% | 33% |
| 8. Computers help people make decisions by telling them if their problem is important. True, (False), Don't Know. | 53% | 53% | 61% | 60% |
| 9. Computers are able to think in every way just like people. True, (False), Don't Know. | 71% | 72% | 84% | 80% |
| 10. Some computers have good and bad feelings like people. True, (False), Don't Know. | 71% | 70% | 79% | 80% |

* The correct answer for each question is enclosed in parentheses.

Computer Anxiety

The level of anxiety or stress that a respondent attributes to computers is measured by this five item scale. Larger values on this variable correspond to greater levels of anxiety about computers. The reliability of this scale at pretest was .67 and at post-test .73.

Computer Self-efficacy

The extent to which a person feels confident about his or her ability to deal with computers is the underlying concept for this scale. The reliability was .70 at pretest and .75 at post-test. The test retest correlation was .70.

Self Esteem

Using selected items from Rosenberg's (1965) scale, we developed a five item measure of one's overall self esteem. The reliabilities are over .70 and the test retest correlation is .84.

State Anxiety

Temporal anxiety or state anxiety was measured using the Speigleberger short scale of 5 questions (see Sieber, O'Neil, and Tobias, 1977). This scale has been used extensively in educational research and attempts to measure undifferentiated, temporary discomfort or anxiety. The reliabilities are fairly high (.74 and .8) but the test retest correlation is low (.36).

Locus of Control

Eight items were selected from the Nowicki and Strickland (1973) test of internal (vs. external) locus of control. The items are scored in the direction of greater internality; i.e., higher scores represent a likelihood of attributing events to sources internal to the individual.

The reliability was .59 and it was measured at pretest only.

## RESULTS

Looking first at the question of how much science learning can be produced from a short CAI lesson, Figure 8 and Tables 31 and 32 show that students at post-test, on the average got 7 out of 10 items right. The unexposed control group answered less than 3 items correctly, which is a performance level that could be produced by chance alone. While the performance level went down to about 5 out of 10 at follow-up, this level is still nearly twice that of the control group.

Performance on the computer awareness test is less dramatic in its shifts. From pre- to post-test the performance remained essentially the same at 5.6 out of 10 items correct (Figure 9). But as reported in Table 32, the level of computer mystique actually increased slightly from pre- to post-test. On the remaining computer awareness items, the performance level would have increased slightly to allow for the resulting lack of overall change in computer awareness. Despite the lack of an increase in computer awareness at post-test, the level of computer awareness six months later at follow-up testing was up to 6.4 out of 10. This rise is 0.8 points, which is equal to 10 standard errors and thus is clearly a significant improvement. At follow-up testing the computer mystique was down to 0.8, which is slightly below the initial pre-test level but equal to the control group level (Table 31). The control group level of computer awareness was 6.0 (see Figure 9), which is significantly lower than the exposed group at follow-up but higher than the pre-test level. The pre-test was six months earlier so this later difference may be due to incidental learning over the summer period.

The three scales measuring attitudes toward computers do not reveal

Figure 8

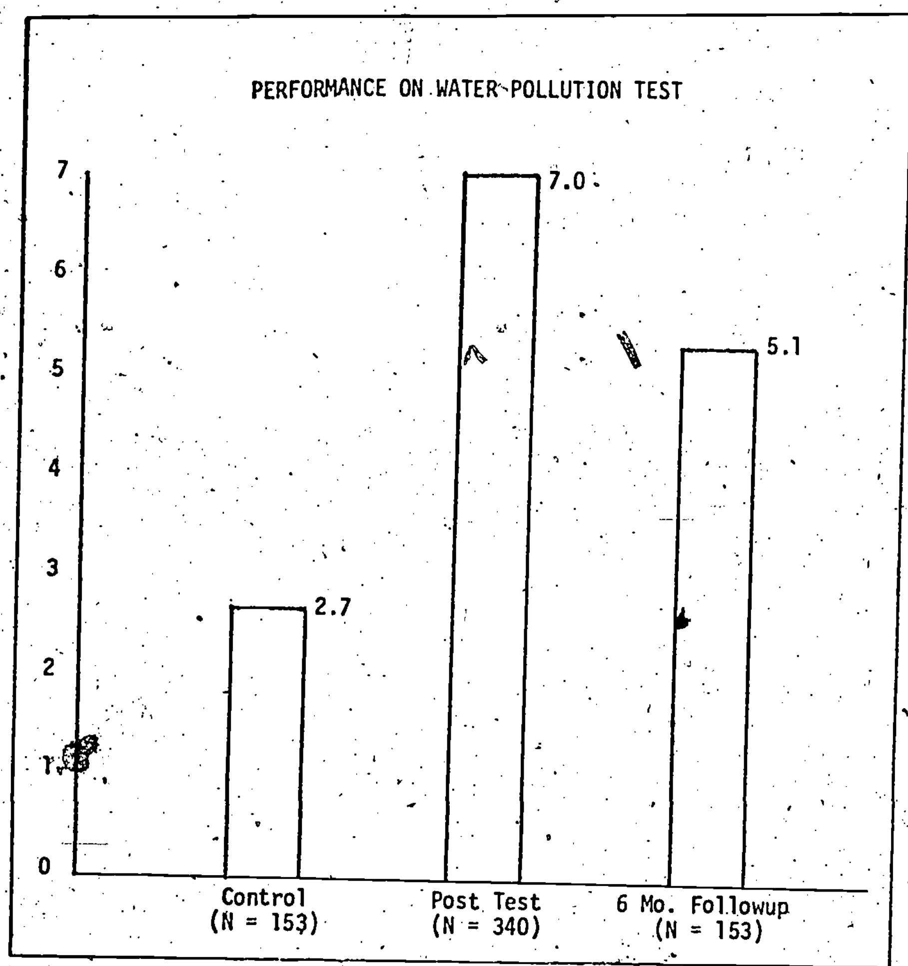

PERFORMANCE ON WATER POLLUTION TEST
7
6
5
4
3
2
1
0
7.0
5.1
2.7
Control
(N = 153)
Post Test
(N = 340)
6 Mo. Followup
(N = 153)

Table 31

T-TESTS BETWEEN CAI EXPOSED AND NON-EXPOSED GROUPS
SHOWING OVERALL EFFECTS (N = 369)

| | | Exposed (N=216) | | Control (N=153) |
|---|---|---|---|---|
| Pollution Test | $\bar{x}$ | 5.1 | | 2.7 |
| | SD | 2.1 | | 2.3 |
| | t-value | | 8.7** | |
| Computer Awareness | $\bar{x}$ | 6.4 | | 6.0 |
| | SD | 2.3 | | 2.1 |
| | t-value | | 1.64 | |
| Computer Mystique | $\bar{x}$ | 0.8 | | 0.8 |
| | SD | 0.9 | | 0.8 |
| | t-value | | -0.53 | |
| Computer Enjoyment | $\bar{x}$ | 3.4 | | 3.3 |
| | SD | 0.8 | | 0.8 |
| | t-value | | 0.9 | |
| Computer Anxiety | $\bar{x}$ | 2.0 | | 2.3 |
| | SD | 0.6 | | 0.7 |
| | t-value | | -3.55** | |
| Computer Self-Efficacy | $\bar{x}$ | 3.4 | | 3.0 |
| | SD | 0.6 | | 0.7 |
| | t-value | | 3.1* | |
| Self-Esteem | $\bar{x}$ | 3.7 | | 3.7 |
| | SD | 0.6 | | 0.6 |
| | t-value | | 0.4 | |

* $P \leq 0.05$; ** $P \leq .01$

Table 32

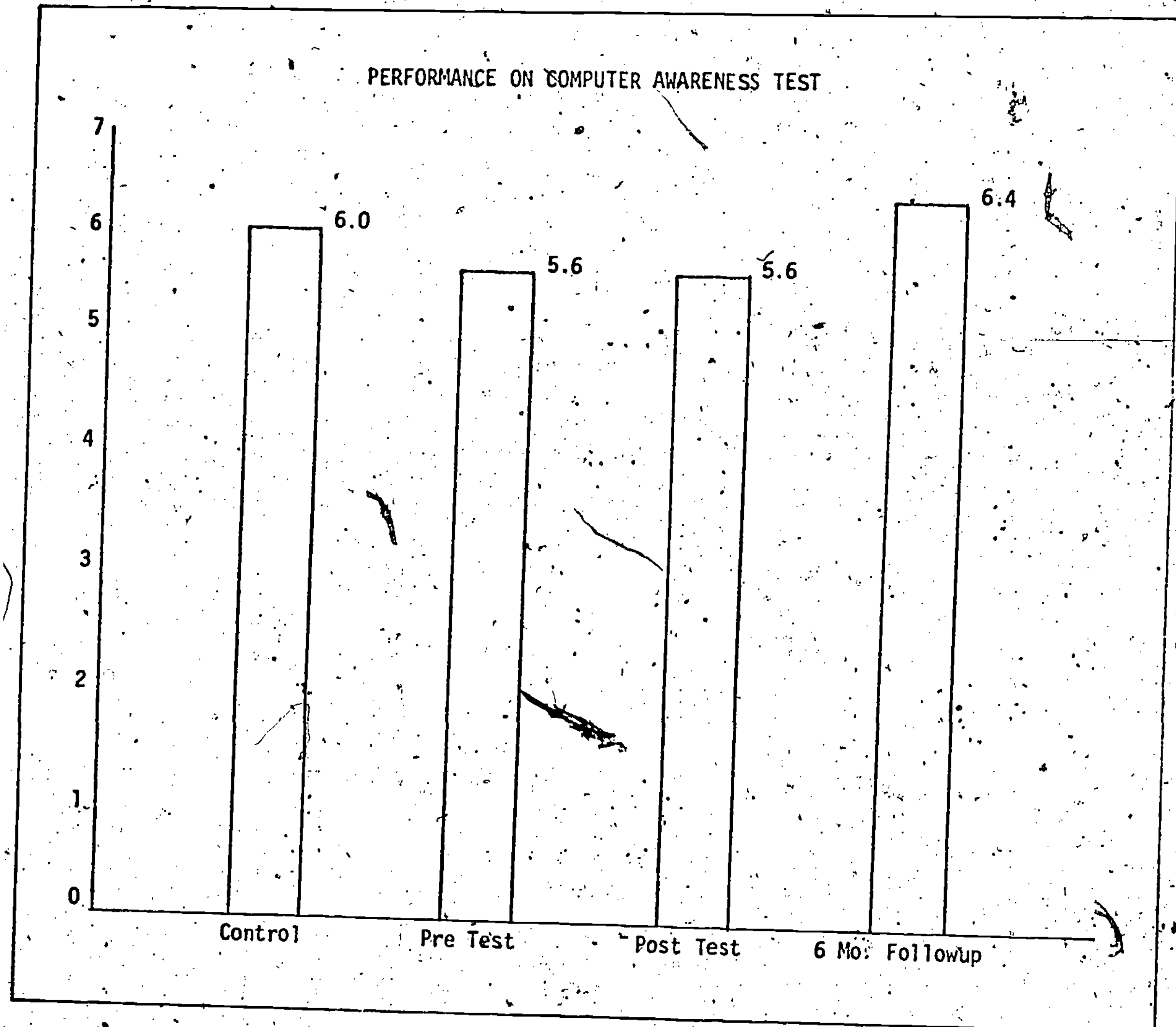
## KNOWLEDGE AND ATTITUDE CHANGE OVER TIME

| Scale | | Pre Test | | Post Test | | Six Month Followup |
|---|---|---|---|---|---|---|
| Pollution Test | $\bar{x}$ | - | | 7.0 | | 5.1 |
| | SD | - | | 2.2 | | 2.4 |
| | t-test | - | | | (.08)+ | |
| Computer Awareness | $\bar{x}$ | 5.6 | | 5.6 | | 6.4 |
| | SD | 2.3 | | 2.2 | | 2.3 |
| | t-test | 1 | 1.23 | | (.08)+ | |
| Computer Mystique | $\bar{x}$ | 0.9 | | 1.1 | | 0.8 |
| | SD | 0.8 | | 1.0 | | 0.9 |
| | t-test | | 3.3* | | (.06) | |
| Computer Enjoyment | $\bar{x}$ | 3.5 | | 3.7 | | 3.4 |
| | SD | 0.7 | | 0.7 | | 0.9 |
| | t-test | | 9.1** | | (.05) | |
| Computer Anxiety | $\bar{x}$ | 2.1 | | 1.9 | | 2.0 |
| | SD | 0.6 | | 0.6 | | 0.7 |
| | t-test | | -7.4** | | (.04) | |
| Computer Self-Efficacy | $\bar{x}$ | 3.3 | | 3.6 | | 3.4 |
| | SD | 0.6 | | 0.6 | | 0.6 |
| | t-test | | 9.1** | | (.04) | |
| Self Esteem | $\bar{x}$ | 3.7 | | 3.8 | | 3.7 |
| | SD | 0.6 | | 0.6 | | 0.6 |
| | t-test | | 3.5* | | (.04) | |
| State Anxiety | $\bar{x}$ | 1.7 | | 1.5 | | - |
| | SD | 0.5 | | 0.5 | | - |
| | t-test | | 5.96** | | (.03) | |

+ The number within parentheses is one standard error of the post Test $\bar{x}$.

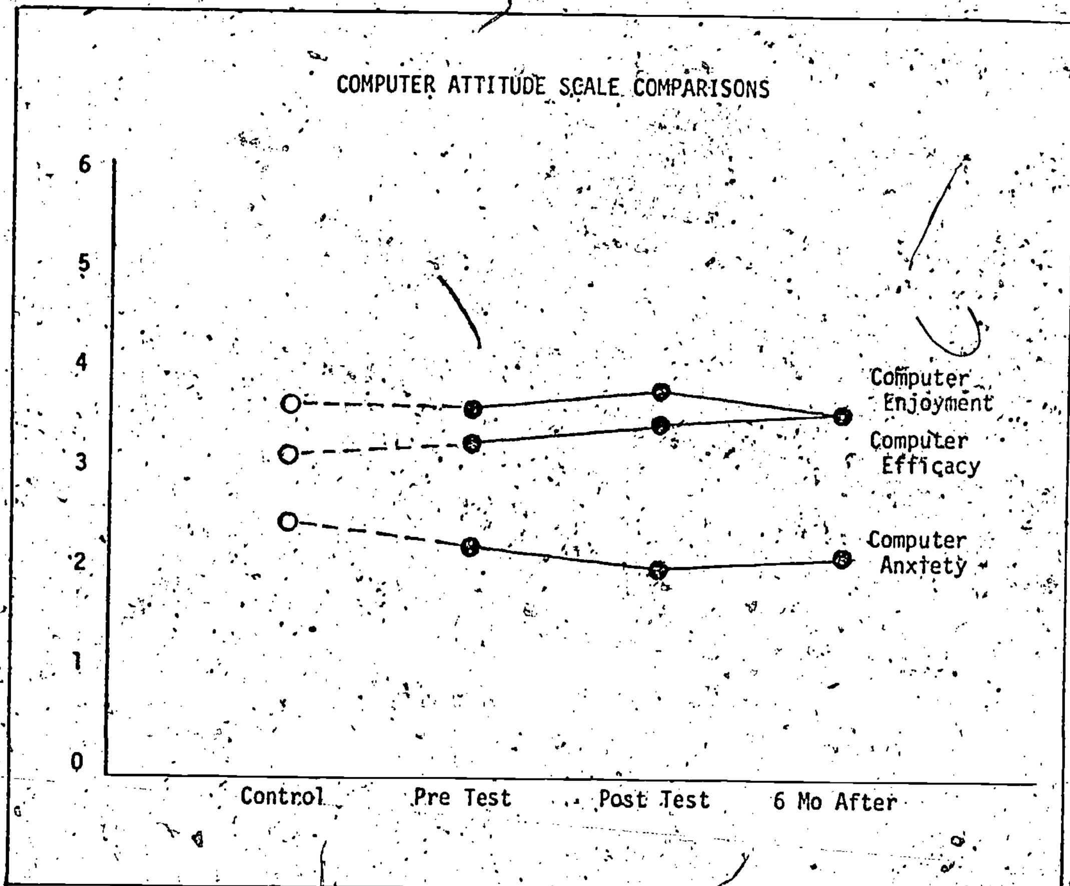
* $P < .05$
** $P < .01$

Figure 9




dramatic differences (Figure 10). Nonetheless, the short term or immediate impact of the CAI experience was a significant reduction in computer anxiety and signficant increases in computer enjoyment and computer efficacy (Table 32). After six months these changes diminished for all three attitude measures but especially for the enjoyment scale. The exposed group, after six months, was significantly less anxious about computers ($p < .01$) and more self-efficacious about computers ($p < .05$) than the control group.

Figure 10




The two treatment variables, malfunction and enriched display, did not produce significant main effects nor interaction effects on computer awareness or the computer attitude scales with one exception: computer self-efficacy. While computer self-efficacy was slightly higher at post-test than at pre-test for those experiencing a malfunction, there was a significantly higher gain for those <u>not</u> experiencing a malfunction (Tables 33 and 34). The presence or absence of an enriched display, however, did not result in a difference in the gain of computer self-efficacy. While there were no significant interaction effects (see Table 33), there were significant main effects for sex, grade, and prior exposure. As reported in Table 34, the level of computer self-efficacy

Table 33

5 WAY ANALYSIS OF VARIANCE OF CHANGE (GAIN) IN COMPUTER SELF-EFFICACY FROM PRE TO POST TEST

| Source of Variation | SS | DF | MS | F | Prob. |
|---|---|---|---|---|---|
| A. Malfunction | 0.73 | 1 | 0.73 | 3.65 | .05 |
| B. Enriched Display | 0.00 | 1 | 0.00 | 0.00 | .98 |
| C. Sex | 1.60 | 1 | 1.60 | 7.98 | .01 |
| D. Grade | 1.31 | 1 | 1.31 | 6.59 | .01 |
| E. Exposure | 1.09 | 1 | 1.09 | 5.44 | .02 |
| 2 Way Interactions | 2.79 | 10 | 0.28 | 1.39 | .18 |
| 3 Way Interactions | 0.447 | 10 | <0.04 | 0.22 | .99 |
| 4 Way Interactions | 1.33 | 5 | 0.27 | 1.033 | .25 |
| 5 Way Interaction | 0.18 | 1 | 0.18 | 0.88 | .35 |
| Residual | 60.07 | 300 | 0.20 | 1.53 | .04 |
| Total | 69.55 | 331 | 0.21 | | |

Table 34

COMPUTER SELF-EFFICACY PRE-TEST AND GAIN SCORES BY TREATMENT VARIABLES, SEX, GRADE AND PRIOR EXPOSURE (N = 340)

| | Pre-Test $\bar{X}$ | Pre-Test (SD) | Gain Scores $\bar{X}$ | Gain Scores (SD) | N |
|---|---|---|---|---|---|
| Malfunction | - | - | .28 | (.47) | 170 |
| No Malfunction | - | - | .18 | (.44) | 170 |
| Enriched Display | - | - | .23 | (.46) | 170 |
| No Enriched Display | - | - | .23 | (.46) | 170 |
| Male | 3.4 | (.62) | .17 | (.45) | 183 |
| Female | 3.2 | (.55) | .30 | (.45) | 157 |
| Grade 9 | 3.4 | (.61) | .16 | (.49) | 166 |
| Grade 11 | 3.2 | (.58) | .29 | (.43) | 175 |
| Prior Exposure Low | 3.2 | (.58) | .28 | (.46) | 180 |
| Prior Exposure High | 3.5 | (.58) | .18 | (.44) | 160 |
| All Students | 3.3 | (.60) | .23 | (.47) | 340 |

was more likely to go up for females than for males, for 11th grade students than for 9th grade students, and for those with low prior exposure as compared to those with high prior exposure. These differential gains are partially explained by the level of computer self-efficiacy brought into the situation at pre-test. The pre-test means reported in Table 34 show that at pre-test, males had higher computer self-efficacy than females, grade 9 students than grade 11 students, and high prior exposure students compared to low prior exposure students. Thus the groups with the lowest initial efficacy scores experienced the highest gains during the course of the experiment.

The planned malfunction, while not leading to changes in general attitudes toward computers, did affect specific perceptions. Subjects were asked what they thought caused the breakdown: "something in the computer system, something you did or didn't do, some combination of the computer system and you." As reported in Anderson, et. al. (1979) 42% of the students blamed themselves, 26% blamed the computer, and 32% said it was both. The students who experienced a malfunction also tended to generalize from this single experience to other situations, as can be seen in Table 35. Even after six months, the students who had encountered the system failure were more likely than the other students to anticipate other computers to fail.

## DISCUSSION

### Science Learning

The results definitely support the claims that a brief CAI module is effective for science learning. The students who were exposed to the water pollution program retained much of the learning even six

Table 35

EFFECTS OF MALFUNCTION UPON RESPONSES TO THE QUESTION: SUPPOSE YOU GET A JOB WHERE YOU HAVE TO WORK WITH COMPUTERS. WOULD YOU EXPECT THE COMPUTERS YOU WORK WITH TO HAVE BREAKDOWNS: VERY OFTEN, FAIRLY OFTEN, FAIRLY INFREQUENTLY, VERY INFREQUENTLY?*

| | Malfunction | No Malfunction | All Exposed Students |
|---|---|---|---|
| very or fairly often | 30% | 13% | 22% |
| fairly infrequently | 43% | 44% | 43% |
| very infrequently | 27% | 43% | 35% |
| | 100% (108) | 100% (108) | 100% (216) |

*Data are based on the survey six months after the experiment.

N = 207

months afterward (Figure 8). The students also voluntarily described their feelings to the laboratory assistant; typical comments were: "This was a lot more fun than I expected." and "I wish that I could take all my courses like that." Only a very few students said that they thought it was "dull" or "too long." The generally positive response of the students probably is largely a consequence of the novelty of the system and the game-like character of some of the material. On the other hand, the APOLUT unit did not allow many student choices nor did it allow students to branch back through the material. Fisher (et. al., 1975) and others have warned against lack of student choices in the design of instructional material; thus the generally positive results of this experiment, in both the affective and cognitive areas, is especially impressive.

## Computer Learning

Previous research and theory are not instructive with regard to whether or not we should expect computer literacy to improve as a consequence of a brief exposure to CAI. Nonetheless we hypothesized that such learning would occur on the basis of increased motivation and attentiveness. The data presented in Tables 30 to 32 and Figure 9 reveal that computer learning definitely did occur but that it was not evident until six months after the learning situation. Six months later the level of computer awareness was up and the level of computer mystique was down. This is in direct contrast to the pretest findings that immediately after the learning situation computer mystique was up and computer awareness was unchanged. The individual test items (Table 30) confirm that most items follow these trends. It would appear that exposure to CAI became a triggering event which led students to either seek out new, relevant information about computers or made them more receptive to available information.

Most of the students had previously been exposed to at least a minimal form of instructional computing but it had consisted mostly of teletype access to a large, remote computer. The experience of spending time with a microcomputer that not only asked questions and displayed information but also rapidly drew graphs and color pictures not surprisingly had an eye opening or "gee whiz" effect on many students. Perhaps the combination of novelty and "power" produces a sense of awe or amazement, but high school students in an age of high technology are not easily duped by gadgetry. Consequently we presume that this sense of computer mystique created by the brief computer lesson left the students with an agitating question about what computers really can and cannot do. Such an issue could well have been the motivating force behind the increased computer awareness they expressed six months later.

### Attitude Change

While the computer learning situation left students with a slightly higher computer mystique and more favorable feelings about computers in general, the level of expressed stress and anxiety (measured by "State Anxiety" scales) was significantly lower as was their computer-specific anxiety. Possibly an encounter with a "magical" microcomputer is comforting because it makes things relatively simple and structured for the student. Or perhaps it is simply a matter of relieving fears of the unknown. Whatever the reason, the reduction in computer anxiety and the confidence in dealing with computers (computer self-efficacy) persisted over a six month period (Tables 31 - 32. This is especially significant in light of the fact that the level of general attitude toward computers (computer enjoyment) did not persist. In the six month follow-up study, the level of computer enjoyment is not significantly different for the experimental and the control groups; but there is a significant difference for computer anxiety and computer self-efficacy. Six months later, those students who spent only 15 - 20 minutes with the microcomputer-delivered APOLUT lesson were less anxious about computers and more confident of their own computer capacity than students who did not experience the brief CAI lesson on the microcomputer.

### Effects of Enriched Display

None of the attitude or knowledge indicators included in the study demonstrated an effect due to enriched display. One cannot conclude from this that graphics and color make no difference in CAI. The enriched display, as described in a previous section, consisted of an animated fish, a multicolored mosaic, and two-color time series graphs. It would appear that we were presumptuous to call these features "enriched displays" rather than graphical gimicks. Actually, the situation is more complex than appears on the statistical surface. For one thing, the color displays on the APPLE II microcomputer often have less clarity and readability than the white-on-black displays. Secondly, the added animation slowed down the online plotting of dissolved oxygen levels over time. The supposed visual advantage of an animated fish swimming across the screen slowed the simulation/graphing activity down by a few seconds. Thirdly, and perhaps more importantly, the animated fish had a peripheral role in the instructional material. If the dissolved oxygen level got dangerously low, the fish stopped and turned into a skeleton, but the graph illustrated this condition anyway. All of the supposedly enriched features were unessential to the instructional process. The animated fish might even have detracted the student from the primary content of the lesson. Thus the enriched features of color and graphics may have the potential to produce affective and cognitive advantages but likewise they may result in communication disadvantages as well. Our failure to find statistically significant results due to "enriched display" is probably a consequence of multiple effects which cancel each other out yielding no particular (or only trivial advantage) for instruction.

## Effects of Malfunction

Like the "enriched display" treatment, the "malfunction" condition seemed to produce relatively little effect on general attitudes and knowledge. The major exception to this conclusion is the finding that a difference in computer self-efficacy resulted from the malfunction treatment. Those students encountering a malfunction were less likely than other students to increase their sense of computer self-efficacy as a consequence of their CAI experience. The difference between those encountering a malfunction and those lacking such a treatment was substantial with respect to their sense of efficacy (Tables 33 and 34), and this effect persisted afterward, at least until the six month follow-up testing.

With the exception of computer self-efficacy, the malfunction introduced into the experiment would seem to be rather trivial in its impact. The system failure which we introduced was minor in that it was rectified within a matter of minutes and no information was lost. If the students had had to restart the lesson or if they had not been able to complete the unit, the attitudinal effects might have been much greater. Nonetheless, the computer breakdown left many students with revised perceptions of themselves and computers. The ambiguity inherent in the supposed malfunction led many (42 percent) to blame themselves for something they didn't do. No wonder we observed a reduction in computer self-efficacy. The minor malfunction episode seems to have resulted in less trust in computers as well as in their ability to deal with computers. As reported in Table 35, the students encountering a breakdown are more likely to expect computers generally to malfunction.

## CONCLUSION

While the positive impact of computer based learning has been previously substantiated when students spent considerable time with the computer, this study demonstrates that both affective and cognitive benefits can accrue from even a very brief (15-20 minutes) encounter with

CAI. While this finding is impressive and higly favorable with respect to CAI, it must be evaluated within the context of the experimental environment. For the most part, the experiment simulated a typical laboratory or classroom environment. It should be stressed that while students were told they were free to discontinue the experiment at any time, they may have felt constrained by the novelty of the situation and the laboratory assistant nearby. Students taking the APOLUT lesson under different instructional conditions might react differently. For instance, if the students expected their performance to affect their course grades, they might react more negatively toward the CAI experience. Nonetheless, the favorable student comments and the statistical results of the attitude scales suggest that CAI modules such as APOLUT have potential for many classroom situations.

Even if the students had not learned what the CAI lesson attempted to teach them, our experiment indicates that they learned something about computers. Computer literacy apparently is the by-product of different types of computer experiences. What is most intriguing about the microcomputer CAI experience we studied is that the mystique of the technology seems to spawn a search for information about what computers can and cannot do. Even the students who previously had worked with computers and could write programs succumbed to the "magic" of the micro-computer. The graphical wonder of the lively, color screen evokes an attitude of awe. Perhaps the jolt of such a quasi-religious encounter provides the motivation to learn the facts behind this unusual situation.

The major outcome of this experimental research is progress toward a methodology for understanding the human response to information technology. Many attributes of persons, computers, and person-computer relationships have been identified, measured, and found to interrelate in complex ways. It is impossible to say that microcomputers have no impact. The transition from the traditional, large-scale, timeshared computing to new forms of small-scale, personal computing involves much more than smaller circuit boards and lower prices.

## REFERENCES


Anderson, R., Klassen, D., Johnson, D., & Hansen, T. THE MINNESOTA LITERACY TESTS: A TECHNICAL REPORT ON THE MECC COMPUTER LITERACY FIELD STUDY, Minnesota Educational Computing Consortium, St. Paul, MN: 1979.

Anderson, R., Klassen, D., Johnson, D. & Hansen, T. THE COMPUTER MYSTIQUE, Minnesota Educational Computing Consortium, St. Paul, MN: 1980.

Broderick, W. OFF-LINE COMPUTER-AIDED LEARNING PROJECT. London, England: 1974. (ERIC Document Reproduction Service No. ED 129 280).

Brown, B. & Gilman, D. Expresses student attitudes under several conditions of automated programmed instruction. CONTEMPORARY EDUCATION 40, 5 (April 1969), 286-289.

Bukoski, W. & Korotkin, A. COMPUTING ACTIVITIES IN SECONDARY EDUCATION, 1975. (ERIC Document Reproduction Service No. ED 112 935).

Crandall, N. CAI: Its role in the education of ethnic minorities. THE JOURNAL, 1976, 3, 24-27.

Edwards, J., Norton, S., Taylor, S., Weiss, M., & Van Dusseldorp, R. How effective is CAI? A review of the research. EDUCATIONAL LEADERSHIP, November 1975, 33, 147-153.

Ellinger, R. & Brown, B. The whens and hows of computer based instructional simulation. AEDS JOURNAL, 12,2 (Winter, 1979), 51-62.

Fisher, M., Blackwell, L., Garcia, A., & Greene, J. STUDENT CONTROL AND CHOICE - THEIR EFFECTS ON STUDENT ENGAGEMENT IN A CAI ARITHMETIC TASK IN A LOW INCOME SCHOOL. Stanford, CA, Stanford Center for Research and Development in Teaching, School of Education, August 1974.

Hess, R. & Tenezakis, M. THE COMPUTER AS A SOCIALIZING AGENT - SOME SOCIOAFFECTIVE OUTCOMES OF CAI. Center for Research and Development in Teaching, Technical Report 13, School of Education, Stanford University, ERIC Document Number ED 44-942, October 1970.

Hughes, W. A study of the use of computer-simulated experiments in the physics classroom. JOURNAL OF COMPUTER-BASED INSTRUCTION, 1974, I, 1-6.

Jamison, D., Suppes, P., & Wells, S. The effectiveness of alternative instructional media: A survey. REVIEW OF EDUCATIONAL RESEARCH, 1974, 44, 1-67.

Kulik, J., Kulik, C., & Cohen, P., EFFECTIVENESS OF COMPUTER-BASED COLLEGE TEACHING, unpublished paper, University of Michigan: 1979.

Mathis, A., Smith, T., Hanson, D. College students attitudes toward computer-assisted instruction. JOURNAL OF EDUCATIONAL PSYCHOLOGY, 61, (1970), 46-51.

Morgan, C., & Richardson, W. COMPUTER-ASSISTED INSTRUCTION PROGRAM, Rockville, Maryland: Board of Education of Montgomery County, 1974.

Moore, D. About talking typewriters, folk models, & discontinuities. EDUCATIONAL TECHNOLOGY, 20, 2 (Feb. 1980), pp. 15-27.

Murphy, R., & Appel, L. Evaluation of the PLATO IV computer-based education system in the community college. ACM SIGCUE BULLETIN, 1978, 12, 12-28.

Nowicki, S., Jr. & Strickland, B. "A locus of control scale for children," JOURNAL OF CONSULTING AND CLINICAL PSYCHOLOGY, 40 (1973), pp. 148-154.

Rosenberg, M. SOCIETY AND THE ADOLESCENT SELF IMAGE, Princeton, NJ: Princeton University Press, 1965.

Sieber, J., O'Neil, H. Jr., & Tobias, S. ANXIETY, LEARNING, & INSTRUCTION, Hillsdale, NJ: Lawrence Erlbaum Assoc., Publishers: 1977.

Thomas, D. The effectiveness of computer assisted instruction in secondary schools. AE S JOURNAL, 12, 3 (Spring 1979), pp. 103-116.

# CHAPTER 6

## SUMMARY

Chapter 6

## SUMMARY

A growing concern for the public's limited understanding of computers has prompted many computer experts and educators to propose programs to help educate future citizens. The need for these instructional efforts is grounded in the belief that citizens of a society in which computers are a dominant technological force must be computer literate in order to benefit collectively and individually from computer technology. In this sense, computer literacy provides a reservoir of public acceptance, understanding and support upon which computer applications can be built. For the individual, computer literacy makes it possible to deal effectively with computers and situations involving computers.

While computer literacy, in general terms, is the ability of an individual to deal effectively with computers, it is not possible to precisely define the specific knowledge, attitudes and skills one needs in any given situation involving computers or computer supported applications. As a result, educational strategies designed to create or improve computer literacy are extremely diverse and often ill-defined. This research project was conducted in order to help provide a conceptual framework for those interested in the development of computer literacy among secondary school students. Rather than attempting to develop a universal, absolute definition of computer literacy, however, we have outlined the components or dimensions of computer literacy in broad terms and expressed them in the form of learning objectives. These objectives, in addition to providing a framework for our assessment of computer literacy among secondary school students are designed to assist in the creation of meaningful educational programs. The objective have been disseminated to these audiences via several different publications including The Mathematics Teacher and a soon to be released monograph published by the National Education Association and it is already clear that they are beginning to serve one of the purposes for which they were intended.

Our examination of instructional computing and teacher attitudes toward computer literacy leads us to conclude that while there is strong teacher support for computer literacy, this support does not often manifest itself as a specific classroom activity or program to improve computer literacy among students. While some teachers, often on their own initiative and with minimal guidance and support, have developed instructional programs dealing with the uses and applications of computers in society, such programs are relatively uncommon.

The survey of teachers and the subsequent analysis of the data shows that while the availability of computer equipment is important, teacher training and attitudes toward computing and computer literacy are most critical in determining teacher involvement with instructional computing. We sense that many teachers feel ill-prepared to meet the challenge of computers and of computer literacy. Many of the science and mathematics teachers surveyed admitted that they did not feel adequately prepared to deal with computers. While this admission may simply reflect the quality of their computer-related education and training, we suspect that it reflects a more fundamental lack of awareness and understanding of computers. Without computer literate teachers, instructional activities to help students become computer literate are likely to be poorly designed and ineffective or, even worse, may be inaccurate and misleading.

This research effort resulted in the development of comprehensive and systematic tests of the various components of computer literacy. The results of the analysis of these tests validate the instrument. This instrument has already served as the basis for other attempts to measure computer literacy at the secondary school level and we trust that it will continue to be of use to classroom teachers and researchers.

Test data collected from over 1000 students suggests that computer literacy among secondary school students is quite low and that knowledge is unevenly distributed across the several dimensions of computer literacy. Students entering classes involving the computer, for the most part are not able to clearly demonstrate that they understand computers, the uses and applications of computers in society, and the potential effect of computers upon their daily lives. Generally speaking, their knowledge of the less technical aspects of computers and computer use was greater than the more technical features of computers.

Unfortunately, this situation does not improve dramatically after instruction involving computers. While students do leave courses which include instructional computing activities and computer topics with an expanded awareness and understanding of computers, the increase is not large.

While student knowledge is undeveloped, attitudes toward computers are generally quite positive. This is true both before and after courses involving computers and computer topics.

Our research revealed that teachers use computers in the classroom in a variety of different ways and that they follow a number of paths in their attempt to create computer literacy among students. While all of these different approaches and strategies produce some significant student learning about computers, the more comprehensive approaches produce the most gain in performance across all the dimensions of computer literacy. Courses and units which included computer programming, as well as an examination of the role of computers in society, produced the greatest gains. Some improvement in computer awareness and knowledge was evident in courses or instructional units which used the computer in a relatively minor way. Computer assisted instruction, for example, produces a small improvement in computer literacy even though such learning was not the primary reason for computer use.

Because computer use in education (computer assisted instruction) is often considered a vehicle for the development of computer literacy, we conducted a controlled experiment to help identify this impact. The experiment confirmed that both cognitive and affective learning results from involvement in a relatively brief CAI lesson. The experiment also demonstrated that these computer literacy impacts occur despite minor variations in system features.

Perhaps the most important outcomes of the research project are the tools (objectives, tests, etc.) which have been designed and the opportunities for further research which are suggested by the findings. Many features of current educational processes have been identified, measured, and found to interrelate in complex ways. The acquisition of computer knowledge is a diverse and multi-faceted process. Additional research is needed to isolate and contrast specific instructional computing techniques. For example, microcomputer based mathematics drills could be compared with drills on remote terminals to determine whether or not there are differences in incidental learning, especially unlearning of computer myths. Such ongoing research should not disuade educators from developing curriculum materials and developing improved learning programs. Research and development on instructional processes must be initiated in order to keep pace with the rapidly evolving machinery of computing.

APPENDIX A

"INSTRUCTIONAL COMPUTING:

ACCEPTANCE AND REJECTION BY SECONDARY SCHOOL TEACHERS"

REMOVED DUE TO COPYRIGHT RESTRICTIONS

APPENDIX B

"THE COMPUTER MYSTIQUE"

# THE COMPUTER MYSTIQUE*

August 1979

Ronald E. Anderson
Daniel L. Klassen
Thomas P. Hansen
David C. Johnson

Minnesota Educational Computing Consortium
2520 Broadway Drive
St. Paul, Minnesota 55113

*Prepared for presentation at the Irvine Conference on the Social Impact of the Computer

This report is based on research supported by the National Science Foundation under Grant No. SED77-18658.

Any opinions, findings, conclusions, or recommendations expressed (herein) are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## THE COMPUTER MYSTIQUE

Mystery is the social reality which gives rise to that which societies consider sacred. If, as Ellul (1974:142) argues, "technique denies mystery a priori," then a technologically dependent society may shift its sense of the sacred. Indeed, one such cultural evolution that has occurred is an adoration of technology even to the point of attaching mystery, magic, and a sense of the sacred to technique itself. This perspective, which we would describe as a technological mystique, is epitomized in attitudes toward the computer and its role in society. The computer more than any other technology evokes a sense of awe and mystery. No other machine has ever been so central to the control of social systems. No other machine has imitated mental functions so extensively. The computer can tirelessly process information at such incredibly rapid speeds that it is often described as not only human-like but superhuman. Furthermore, no one knows the future boundaries of computer power; we have few guides for guessing how close to or beyond human capability the computer will evolve. It is no wonder that well informed people approach this new machine with a quasi-religious attitude accepting myths which erroneously extend the capabilities of actual computer systems.

We define the <u>computer mystique</u> more precisely to be an orientation to computer technology based upon beliefs that it can perform functions that in fact it cannot perform. The computer mystique includes, but is not limited to, anthropomorphic myths that computers have emotions and intuitions. More basically the computer mystique encompasses any assessment of a computer system which overestimates its actual capability.

This conception of the computer mystique implies both cognitive and affective aspects; i.e., both a collection of myths and an accompanying feeling of fear and awe. For instance, jokes about computers often combine myth with fear (Anderson, 1978). Myths have historically been intimately connected to the mysterious and the sacred, and the substance of mythologies is generally liminal, which means that they clarify an identity or a transition (Turner, 1968). The liminal identity issues posed by the computer are questions as to the dictinctions between computers and people. Malinowski (1925), Jung (1953), and Eliade (1964) maintain that mythology always contains an element of truth or reality. The "truth" contained in mythology can be discovered by examining its social and cultural context. The "truth" in computer mythologies lies in the inherent incomprehensibility and complexity of computer systems such that it is impossible to be free of speculation regarding the precise power of computer systems. Weizenbaum (1976) expands upon this point:

> Our society's growing reliance on computer systems that were initially intended to 'help' people make analyses and decisions, but which have long since both surpassed the understanding of their users and become indispensable to them, is a very serious development. ...Decisions are made with the aid of, and sometimes entirely by, computers whose programs no one any longer knows explicitly or understands. (p. 236)

Thus it is not possible to dismiss the computer mystique as simply a matter of ignorance. To some extent the mystique is a consequence of real complexities in the computer technology and real mysteries regarding its future. Another source of the mystique is dissensus among the experts; e.g., highly respected computer scientists such as Raphael (1976) describe the computer as "thinking" and "smart," while most computer scientists abhore such metaphors.

One of the serious implications of the computer mystique is its association with power and authority. "Blind faith" in the computer may lead to unwitting and potentially harmful surrender of control to computer systems. Dunn and Zimmerman (1979) claim that in criminal justice policy decision-making, there has been an increasing reliance on computer models and that this has resulted in loss of control and interjection of inappropriate values. Marshall and Maguire (1971) performed an experiment which demonstrated that subjects would quite easily accept the computer system as an authority even when it is not obviously appropriate to do so. Mowshowitz (1976) points out how this tendency may be a broader cultural tendency.

> The belief in the social necessity and inevitability of computer utilities, databanks, management information systems, and sundry computer applications is not based on reason alone. It is the reflection of a political faith built into the scheme of modern history, with an internal logic akin to that portrayed in the Theatre of the Absurd. (p. 314)

Faith in computer systems, which may flow from the computer mystique, must be considered in light of its implication for power and control.

The computer mystique is not simply a consequence of lack of education. Neither the computer sophisticate nor the computer naive is free of computer mythology. The mystical commitment and ritual of the "compulsive programmer" (Weizenbaum, 197: p. 131) are reminescent of the totemism that Durkheim (1912) studied in Australian tribes. Durkheim identifies four elements of totemism: an emblem, an object of the emblem, a clan that adopts the emblem, and an associated world view. The computer world analogy is obvious: the computer serves as a totemistic emblem representing the "magic" of electronics; the computer industry has adopted the emblem even to the point of referring to themselves as computer people; and, as elaborated by Turkle (1979), the computer worker uses the computer metaphor to create unique conceptions of the world. Not every computer worker can be called a totemist, of course, but totem worship tendencies are documented in a variety of sources. Schneider (1974), for instance, describes the optimistic faith of some computer users as follows:

> Most people who have close relationships to computers habitually lunge blindly ahead from one disaster to another, bloody and happy, sure that success is only one day or week away -- certainly not more than a month.

The computer naive, in contrast to the computer expert, is best typified by the child who as yet has not learned that there is a distinction between a person and a computer robot. The drawings of young children show a natural blending of human and mechanical features but as children grow older, their drawings, except in cartoons, depict computers with fewer human characteristics. The childhood fascination with the magic of the computer may well have some similarity to the magical worlds of the "mad scientist" and the "compulsive programmer."

The conventional wisdom of computer science education seems to say that the computer mystique is simply a reflection of computer illiteracy; i.e., a lack of education and a lack of exposure to computers. Our view, in contrast, argues that the computer mystique is a social reality with important cultural meanings. One implication of this perspective, which is informed by the sociology of mythology, is that the computer mystique is not only related to one's knowledge and maturity but also related to one's attitudes, beliefs, and experiences.

While we did not design a study to test these contrasting hypotheses about the computer mystique, we have data from computer literacy studies that bear upon the questions. Even though our indicators of the computers mystique are limited in scope, it should be possible to access whether or not the concept should be pursued further. Two of our computer literacy studies, one a field study and the other an experiment, included indicators of certain aspects of the computer mystique. Each research study is briefly described below.

## THE COMPUTER LITERACY FIELD STUDY

A major objective of this study was the explication and measurement of the concept of computer literacy. Tests of computer knowledge were devised in five areas: (1) computer hardware, (2) software and data processing, (3) programming and algorithms, (4) applications of computers, and (5) impact of computers. Attitude scales were constructed in eight areas: computer enjoyment, computer anxiety, computer self-efficacy, male sex-typing of the computer, intensity of concern for computer policies, educational use of computers, social values, and technical values. These tests and attitude scales are described along with information on the reliability and validity of these measures in a report by Anderson et al. (1979b).

### METHOD

The tests and scales described above were administered to a sample of 1,401 secondary students (grades 7 through 12) in Minnesota in the fall of 1978. The sample was drawn by creating a list of known high school courses incorporating instruction either <u>about</u> computers or <u>with</u> computers. This list was developed by first surveying all Minnesota secondary school teachers in mathematics, science or business education. The questionnaire asked whether or not they taught any computer-related courses, and if so, what they taught. From the responses of 3,576 teachers we identified 2,668 courses involving instructional computing. The courses were classified into the following categories: (1) use of computer as an instructional tool only, (2) computer programming instruction,

(3) instruction in the application of and the implications of computers without programming instruction, (4) instruction in both programming and applications/implications, and (5) miscellaneous. Courses falling into the first four categories above were further stratified into junior or senior grade level. From each of these eight strata an equal number of courses were randomly sampled with the restriction that a teacher could be drawn only once. The teachers of the courses sampled were asked to administer the tests at the beginning of their course or unit of study and again at the end of the instructional period. Further methodological details are contained in earlier reports (Anderson et al., 1979a; 1979b).

Included in the computer literacy test on computer inpact were three questions that are relevant to the computer mystique. These questions, along with the districtuion of responses, are shown in Table 1. The 11th grade distributions are given separately so as to compare them to the norms of the 1979 Minnesota Statewide Assessment of 11th graders. This statewide assessment is a two-stage, stratified random sample of 11th grade students. A quick comparison of the 11th graders from the two studies shows that the response distributions are very close even though the students in the Computer Literacy Field Study were somewhat unique in that most students were entering a computer-related course at the time they were tested. A number of these courses were, in fact, elective and/or advanced courses. The close similarity of the distributions of 11th grade students in the two sets of data suggests that the Field Stidy sample is none-the-less a representative sample of high school students in Minnesota.

The three questions pertaining to the computer mystique were combined to produce a more reliable measure. Since the correct answer to

Table 1

STUDENT RESPONSES TO QUESTIONS RELATED TO THE COMPUTER MYSTIQUE

| Question | Response | The Computer Literacy Field Study (N=1401): 11th Grade Only | The Computer Literacy Field Study (N=1401): Grades 7-12 | Minn. Statewide Assessment of 11th Graders (N=2535) |
|---|---|---|---|---|
| Computers help people make decisions by providing correct answers to any questions. | True | 47% | 52% | 43% |
| | False* | 39 | 31 | 42 |
| | Don't know | 14 | 17 | 15 |
| | | 100 (162) | 100 (1401) | 100 (2535) |
| Computers help people make decisions by telling them if their problem is important. | True | 18 | 24 | 15 |
| | False* | 53 | 44 | 56 |
| | Don't know | 29 | 32 | 29 |
| | | 100 (162) | 100 (1401) | 100 (2535) |
| Computers are able to think in every way just like people. | True | 10 | 22 | 13 |
| | False* | 80 | 66 | 74 |
| | Don't know | 10 | 12 | 13 |
| | | 100 (162) | 100 (1401) | 100 (2535) |
| Some computers know just about everything. | True | -- | -- | 42 |
| | False* | -- | -- | 41 |
| | Don't know | -- | -- | 17 |
| | | -- | -- | 100 (2535) |
| Some computers have good and bad feelings just like people. | True | -- | -- | 11 |
| | False* | -- | -- | 66 |
| | Don't know | -- | -- | 23 |
| | | -- | -- | 100 (2535) |

* Correct Response

each question is "false," the number of "true" answers was summed to get a score on computer mystique ranging from 0 (no mystique) to 3 (highest mystique). The coefficient of reliability, using Cronbach's Alpha, was found to be .56 for the pre-term testing and .62 for the post-term testing, indicating acceptable internal consistency. A larger, more robust test of computer mystique would be desirable but this analysis indicates that cautious use of this limited measure is warranted.

In order to test the hypothesis that one's computer mystique is not solely a function of one's education, knowledge, and exposure, a regression analysis was performed with computer mystique as the dependent variable and a variety of knowledge, attitudinal and background variables as predictors. An index of prior computer exposure was constructed by giving a weight of "2" for programming experience; a weight of "1" for experience in running but not programming computer programs; and no prior experience was coded "0." The construction of the remaining indicators is described in detail in Anderson et al. (1979b).

## RESULTS

Both Tables 1 and 2 depict a substantial level of computer mystique among the high school students in our sample. As many as 52% show evidence of a mystique in their answer to the first question, "Computers help people make decisions by providing correct answers to any question," for example. In total, 64% give one or more mystique related responses to the questions at the testing prior to instruction and 56% give one or more mystique related responses at the testing following instruction (Table 2). While it may be argued that the questions used to measure the mystique are ambiguous and therefore not valid, each item had very high discrimination ($\bar{X}$ discrimination of 58%) when comparing the upper

Table 2

COMPUTER MYSTIQUE AT PRETEST AND POST -
COMPUTER LITERACY FIELD STUDY (N=1131)*

| | | | Pre term Testing | Post term Testing |
|---|---|---|---|---|
| Computer Mystique | 3 | (High) | 8% | 5% |
| | 2 | (Medium) | 20 | 16 |
| | 1 | (Low) | 35 | 34 |
| | 0 | (None) | 36 | 44 |
| | | Total | 100 (1106) | 100 (1106) |

*The sample was reduced from 1401 to 1106 at post term testing because students were absent, had dropped class, quit school, or the course had been restructured to eliminate computer utilization.

quartile and the lower quartiles. Those who perform very well on all of the computer literacy tests are much more likely to get these items correct than those performing very poorly on all the tests.

As Table 2 reveals, considerable reduction in computer mystique occurred from pre- to post-testing as a result of instruction. Apparently, computer-related instruction, as a whole, produces a reduction in students' tendencies to subscribe to the myths implicit in our measure of mystique.

While classroom instruction, student maturation (as indicated by grade level), and greater knowledge of computer-related matters, all predict lower levels of computer mystique (see Table 3), prior computer exposure does not. The stepwise regression summarized in Table 3 rejected prior computer exposure due to its insignificant contribution to explained variance. Apparently mere exposure to computing, without an accompanying increase in computer literacy, does little or nothing to change the computer mystique. One might assume that the effect of exposure is small because few students had been exposed to computers. This is not the case however because 54% of the students in the sample claimed to have run programs on the computer and 20% indicated that they had written computer programs. Despite this relatively high level of prior experience, it produced no effect in predicting computer mystique once knowledge, grade, and attitude effects had already been taken out.

Three computer literacy/knowledge tests: applications, programming/algorithms, and software/data processing, each explain a significant amount of the variance in the level of computer mystique. These contributions to explained variance are represented by the BETA weights, the standardized b coefficients in the regression equation. It is noteworthy that the test of "knowledge of computer applications" produced

Table 3

REGRESSION ANALYSIS OF PREDICTORS OF COMPUTER MYSTIQUE AMONG MINNESOTA SECONDARY STUDENTS (N=1106)

| Independent Variable + | Zero Order Correlation | Beta * |
|---|---|---|
| 1. Knowledge of computer applications | -.33 | -.29 |
| 2. Grade (7-12) | -.27 | -.13 |
| 3. Humanistic Value Orientation | -.16 | -.08 |
| 4. Attitude toward educational computing | -.06 | .11 |
| 5. Male stereotyping of computer | .18 | .10 |
| 6. Knowledge of programming and algorithms | -.24 | -.09 |
| 7. Knowledge of software and data processing | -.17 | .12 |
| 8. Educational Aspiration | -.20 | -.07 |

$R = .41$; $R^2 = .17$

* All Beta values significant at least at .01.

\+ Variables dropped from the regression equation include
(1) prior computer exposure
(2) sex
(3) computer efficacy
(4) computer anxiety
(5) computer enjoyment
(6) technological value orientation
(7) knowledge of computer hardware

the greatest impact. The test of "knowledge of computer implications" might have produced the greatest effect, but that test was omitted from the analysis because the items used to construct the test of computer mystique were also used in the computer impact test. It suggests that if one is designing instructional programs to reduce misconceptions about computer capabilities that the application of computers should be a major content focus. Understanding of programming and algorithms also contributes to lower mystique, but understanding of "software and data processing" has a reverse effect. While the superficial, zero order correlation of software/data processing knowledge with computer mystique is negative, the BETA value is positive. This reversal could result from software knowledge being a significant predictor of knowledge in one of the other areas. The positive relationship between knowledge and mystique is particularly interesting in that it seems to support the notion that "a little knowledge is a dangerous thing." It also is consistent with our original hypothesis that support for the computer mystique is not just a matter of being uninformed but is also a reflection of cultural meanings and symbols. Whatever the explanation, this pattern of relationships deserves further exploration.

One of the more interesting findings of this analysis are the positive effects of "male stereotyping of the computer" and the negative effects of "humanistic value orientation." The male stereotyping scale is based upon a series of questions concerning the appropriateness of computer work for both sexes. Apparently the tendency to believe in the male mystique and the computer mystique are linked. Possibly the link might be the inclination to accept outside authorities. This interpretation is not inconsistent with the finding regarding humanistic value orientation however. Higher levels of computer mystique are found among these who place relatively less value on the following: freedom, world peace, privacy, love and friendship, and self respect. Those who deem these humanistic values to be relatively unimportant might well seek solutions outside of themselves and hence accept external authorities. One element of the computer mystique, it should be remembered, is uncritical acceptance of the computer as an authority or decision maker.

Most of the variables that were rejected from the stepwise regression analysis were affective or attitudinal scales. Those who believe in the computer mystique are not particularly positive or negative in their feelings about computers. The one exception is with "attitude toward educational computing," and in this case the computer mystique and a <u>positive</u> attitude occur together. The scale on attitude toward educational computing contains items that are more prescriptive than the other scales; e.g., whether or not students should take computer courses. This suggests that those subscribing to the computer mystique may possibly see the computer as a "necessary evil." Perhaps they see it as normative and, hence, something to be familiar with even though they don't enjoy it personally.

Taken as a whole, the Computer Literacy Field Study data support the hypothesis that the computer mystique is caused by more than illiteracy and unfamiliarity. Values, attitudes, and understanding are all necessary to account for variations in acceptance of the computer mystique. Exaggeration of computer power is linked in very complex ways to peoples' feelings and beliefs.

## THE COMPUTER LITERACY EXPERIMENT

This study was designed to investigate the impact of a brief computer based education (CBE) experience on the attitudes, beliefs, and knowledge of different types of students. CBE refers to the administration of a complete course unit via a computer terminal that delivers content, provides exercises, and tests the students (Bailey, 1979). Our strategy in designing a CBE unit for the experiment was to modify a typical classroom computer simulation reducing it to a self-contained unit that can be administered without teacher intervention in a 20-30 minute period. A Huntington II program called POLUT was reconstructed and programmed for the APPLE II microcomputer with high resolution graphics on a color TV monitor. The unit began as a tutorial, presenting textual material on water pollution and the impact of sewage dumping on dissolved oxygen. The program then tested the student briefly before going on to simulate and present graphs of the process of the re-equilibrium of dissolved oxygen after sewage is dumped under various conditions. The last section of the unit contained a "game-like" exercise in which the student is to find the largest sewage dumping rate, or the highest water temperature, that will not kill the fish. To get the answer the student must repeatedly re-run the simulation making progressively better guesses or estimates. After running the program, the student completed a paper and pencil test on the material.

### EXPERIMENTAL DESIGN

A two by two factorial design was used to introduce two treatments: a planned malfunction and enriched display. Slightly more than 80 subjects were randomly assigned to each of the four cells. The malfunction treatment consisted of a system failure about two-thirds of the way through the lesson. At the predetermined time, just after a student had entered a number in response to a question from the computer, the screen was blanked out for two seconds. Next, random characters were printed along the bottom and the top of the screen after which the screen blanked out again except for a flashing cursor. At this point the computer would not respond to any entry on the keyboard except a secret code which only the assistant knew. When the student called for assistance from the assistant, he looked surprised and went over to try to help the student subject. At that point the assistant said: "I don't know what happened but I think I can get it back to where you left off." The assistant then rapidly typed several keys while looking back and forth from the screen to the keyboard. He eventually entered the secret code and the programmed lesson resumed. The assistant then asked, "Is this where you left off?" The student responded and then continued with the computer unit.

The enriched display treatment contained three feaures to increase the communicability of the program. The enriched features were: (1) Animation with a little fish swimming across the top of the screen during the simulation of dissolved oxygen change. Whenever the dissolved oxygen went below the danger level, the moving fish stopped and turned into a skeleton. (2) A multicolor mosaic was drawn on the video screen by the computer at the very beginning of the session. The drawing took 30 seconds to complete and the pollution tutorial began immediately after the drawing was completed. (3) Color was used to differentiate lines in graphs when two lines were displayed simultaneously. This feature was used in two displays about midway through the lesson.

The subjects were students at a Minneapolis high school, which was selected in part because it contained a particularly broad representation of social groups; i.e., race and socio-economic status groups. The sample of 340 subjects was obtained as follows: a list of all 9th and 11th grade student was first compiled; subjects were then randomly drawn from these two lists so as to produce approximately equal divisions on sex as well as grade. Table 4 demonstrates that this objective was achieved.

The experiment was set up in the school's former computer room. Dividers were placed between the four APPLE II computer systems that were used to simultaneously administer the CBE unit. Students were called out of class four at a time to participate in the study. With pre and post-testing the entire session took slightly less than an hour on the average. The collection of data was completed over a two-month period in the spring of 1979.

INDICATORS

In addition to the Malfunction and Enriched Display treatment variables, the following indicators were created from the pre and post questionnaires.

Prior exposure to computers. An index was created from the following three questions:

(a) I have used computers in school. (64% answered 'yes' to this question.)

(b) I have taken a course about computers. (45% answered 'yes.')

(c) I have written computer programs. (47% answered 'yes.')

A "yes" response to any two of the three questions constituted "high exposure" while all others were considered "low exposure." The pattern

Table 4

DISTRIBUTIONS ON THE MAJOR COVARIATES:
SEX, GRADE, AND COMPUTER EXPOSURE

| Sex | | Grade | | Prior Exposure to Computers | |
|---|---|---|---|---|---|
| Male | 53% | 9th | 49% | Low | 57% |
| Female | 47% | 11th | 51 | High | 43 |
| Total | 100% | | 100% | | 100% |

of responses to these three questions was tested for unidimensionality and cumulativeness by performing a Guttman scale analysis. An unusually high fit between the model and the data was found; the three questions produced a coefficient or reproductibility of .95 and a coefficient of scalability of .83. As reported in Table 4, there were 43% classified as "high exposure." Almost all of these students (98%) said they had written computer programs and only 5% of those classified as "low exposure" said they had written programs. Thus, self-reported programming experience is the primary criterion of the exposure index. The level of exposure is slightly higher among our subjects than the average Minnesota high school. The statewide assessment mentioned earlier, found 35% of all Minnesota 11th grade students claiming to have written computer programs. Thus the level of exposure in our sample is only slightly higher than the state average and both the experienced and unexperienced are well represented. Almost all prior exposure to computers had been via teletypes to remote type-sharing systems. Two students had previously used the APPLE II system and these students were dropped from our analysis.

Computer Mystique. An additional item was added to the three items used in the Computer Literacy Field Study to measure the computer mystique. This item is the last one listed in Table 5. Again the incorrect responses to the items were added together to produce a scale score. The reliability of this score, as measured by Cronbach's Alpha coefficient, was .62, which is quite respectable and a slight improvement over the measure used in the Field Study.

Table 5

COLLEGE AND SECONDARY STUDENT RESPONSES RELEVENT TO THE COMPUTER MYSTIQUE

| Question | Response | College Computer Science Students (N=137) | Secondary (9th & 11th Grade) Students Pre | Secondary (9th & 11th Grade) Students Post |
|---|---|---|---|---|
| Computers help people make decisions by providing correct answers to any question. | True | 9% | 55% | 57% |
| | False* | 85 | 29 | 33 |
| | Don't know | 6 | 16 | 11 |
| | | 100 (137) | 100 (340) | 100 (340) |
| Computers help people make decisions by telling them if their problem is important. | True | 12 | 17 | 25 |
| | False* | 81 | 53 | 53 |
| | Don't know | 7 | 31 | 21 |
| | | 100 (137) | 100 (340) | 100 (340) |
| Computers are able to think in every way just like people. | True | 1 | 12 | 16 |
| | False* | 97 | 71 | 72 |
| | Don't know | 2 | 17 | 12 |
| | | 100 (137) | 100 (340) | 100 (340) |
| Some computers have good and bad feelings like people. | True | 2 | 7 | 8 |
| | False* | 93 | 71 | 70 |
| | Don't know | 5 | 22 | 22 |
| | | 100 (137) | 100 (340) | 100 (340) |

Computer Awareness. Ten items were selected from the computer literacy tests used in the Field Study. Questions with relatively low difficulty were selected to determine if learning about computers might occur from a relatively brief exposure to a CBE unit. The reliability (Cronbach's Alpha) on the awareness test was .63 at pretest. The average performance on the computer awareness test was 5.59 (out of 10 possible) correct at pretest and 5.68 correct after the exposure to the computer lesson.

Locus of Control. Eight items were elected from the Nowicki-Strickland (1973) test of internal (vs external) locus of control. The items are scored in the direction of greater internality; i.e., higher scores represent a higher likelihood of attributing events to sources internal to the individual. The reliability (Cronbach's Alpha) of this eight item scale was .59 and this attribute was measured at pretest only.

RESULTS

The mean level of computer mystique was 0.9 before and 1.06 after the exposure to the half-hour CBE science learning unit. The increment in computer mystique was .15, which according to a t-test is significant at the .001 level. As illustrated in Figure 1, subjects' initial levels of computer mystique were negatively correlated with prior computer exposure, self-reported school grades, educational aspirations, and computer awareness. In addition, females, and 9th graders were slightly more likely to express the computer mystique than males and 11th graders, although the differences on sex and grade are not statistically significant and thus could easily be due to chance.

A five-way analysis of variance on the change in computer mystique from pretest to post-test was computed in order to examine the simultaneous effects of the treatment variables (malfunction and enriched

Figure 1

CORRELATES OF COMPUTER MYSTIQUE

Before the experiment computer mystique was higher for those who have the following characteristics:

- female (vs. male)
- 9th grader (vs. 11th grader)
- low prior computer exposure*
- low GPA **
- low educational aspirations **
- high "computer enjoyment"
- low computer awareness **

* Signif. at .05 level
** Signif. at .01 level

display) and sex, grade, and prior computer exposure. The only significant (.01 level) main effect was prior computer exposure and the only significant interaction was between sex and grade. Table 6 gives the mean change in computer mystique by sex and grade; 9th grade males and 11th grade females experience relatively large increased in computer mystique whereas 9th grade females and 11th grade males experience essentially no change. A dummy variable was constructed to represent this complex interaction term and it, along with a number of other variables, was included in a regression analysis predicting the post-test computer mystique (see Table 7). Once the effect of the pretest level of computer mystique was taken out, only computer awareness and the sex by grade interaction term were significant predictors of post-test mystique. Prior computer exposure, locus of control, self-reported grades, and educational aspiration all failed to produce significant effects. Apparently the effect of prior computer exposure was due to differential computer awareness because once computer awareness entered the regression equation, exposure no longer explained a significant amount of variance in computer mystique (post-test).

While the planned malfunction did not result in any effect upon computer mystique, a person's level of computer mystique may affect his/her reaction to a malfunction. After the computer exercise was over, subjects were asked if they experienced a malfunction or breakdown. Table 8 gives their responses to this question and shows that, for the most part, subjects perceived the situation the way it was planned. However, it is interesting to note that 10% of those exposed to a breakdown did not perceive it as such, and a few (3%) who were not exposed actually thought they were.

Table 6.

MEAN CHANGE IN COMPUTER MYSTIQUE BY SEX AND GRADE

| | Grade | | |
|---|---|---|---|
| | 9th | 11th | Total |
| Male | .31 | .04 | .18 |
| Female | .02 | .20 | .11 |
| Total | .18 | .12 | .15 |

Table 7

PERCENT OF SUBJECTS PERCEIVING A BREAKDOWN (Q.89)*

Enriched Display

| | | no | yes | Total |
|---|---|---|---|---|
| Malfunction | no | 3% | 4% | 3% |
| | yes | 91% | 89% | 90% |
| | Total | 47% | 47% | 48% |

Table 8

MULTIPLE REGRESSION RESULTS: PREDICTION OF COMPUTER MISTIQUE (N=333) AT LAB STUDY POSTTEST

| Predictor Variable | Beta | Zero-Order Correlations |
|---|---|---|
| Mystique (pretest) | .55 ** | .63 |
| Computer Awareness | -.23 ** | -.47 |
| Interaction term - sex by grade | -.14 ** | -0.13 |

+ R = .68; $R^2$ = .46

++ Variables dropped from model due to insignificant effects include: sex, grade, prior computer exposure, locus of control, malfunction treatment, enriched display, GPA, and educational aspirations.

* Signif. at .05 level
** Signif. at .01 level

Subj :ts were also asked what they thought caused the breakdown: the computer system, themselves, or both the computer and themselves. Of those perceiving the occurrence of a malfunction, 42% blamed themselves; 26% blamed the computer; and 32% said it was both. Those subjects receiving the enriched display treatment were more likely (49%) to blame themselves than those not given the enriched display (35%). Table 9 reports these data and also shows that one's level of computer mystique magnifies the effect of the enriched condition. Those exposed to the enriched condition and also high in compuer mystique are more likely to blame "self" than are those low on computer mystique (Gamma = .22). An opposite relationship (Gamma = -.20) exists for those not receiving an enriched display treatment.

## DISCUSSION

The results of this experiment show that not only is the computer mystique not just a matter of ignorance but that a very brief exposure to a computer activity can magnify the mythology underlying this mystique. Whereas one would expect exposure to technology to reduce misguided beliefs, we have found an instance where it does just the opposite. Obviously we must look more closely at the situation. The hardware used is relatively new and allows one to produce impressive displays, but when we enriched the display even more by adding animation, computer art, and more color, these did not result in a greater gain in computer mystique. Thus the source of effects probably does not reside in the machine itself but resides in the medium; i.e., the way information is communicated and the way interaction is structured. In the tradition of computer based education (CBE), the computer substitutes for a teacher, even if only for a few minutes. The CBE program not only

Table 9

ATTRIBUTION OF BLAME FOR BREAKDOWN BY COMPUTER MYSTIQUE AND BY ENRICHED DISPLAY FOR THOSE EXPOSED TO PLANNED MALFUNCTION (N = 160)

No Enriched Display Only

| | | Mystique: Low | Mystique: High | |
|---|---|---|---|---|
| Attribution of Breakdown | Computer or both | 59% | 68% | 65% |
| | Self | 41 | 32 | 35 |
| | | 100 (29) | 100 (50) | 100 (79) |

GAMMA = -.20

Enriched Display Only

| | | Mystique: Low | Mystique: High | |
|---|---|---|---|---|
| Attribution of Breakdown | Computer or both | 58% | 47% | 51% |
| | Self | 42 | 53 | 49 |
| | | 100 (24) | 100 (57) | 100 (81) |

GAMMA = +.22

* Mystique is dichotimized as between 0 and 1.

supplies information but structures the flow of interaction. As such the CBE program acts as a control system and by default appears to take on the authority of the human teacher. Not all CBE programs exert as much power over the sequence of learning as our POLUT program. For instance, our program never asked the student if he/she wanted to stop and read up on related topics before continuing.

CBE is often highly structured in order to maximize efficiency. As such it may produce meta-communications that imply control. For instance, the lack of a choice to exit from a program implies the meta-communication message "You have to go on." These interaction mechanisms may well lead students, or at least some of them, to attribute authority and power to the computer system beyond its actual power. Overextending another's authority, especially if that other's authority is ambiguous, may well result in an exaggeration of his/her/its capabilities. Studies of children's perception of authority have found acceptance of public authorities; e.g., president, policeman, and teacher to occur well before adolescence (Easton and Dennis, 1969). Not only is there acceptance but a sense of respect and legitimation which is learned in role relationships involving authority "figures." The ability to differentiate legitimate from illegitimate authorities is a skill which requires considerable time and experience. Consequently, we should not be surprised that some have difficulty making such judgments in the face of an ambiquous authority such as a computer system.

The responses we found in connection with attributions of blame for the malfunction lend support for our supposition that acceptance of authority and commitment to the computer mystique go hand in hand. The students who were exposed to the enriched system apparently were so impressed by the power of the system that they chose to trust the computer more than themselves. In the face of uncertainty, their attribution of blame to themselves was implicitly an acknowledgement of the computer's superiority in the situation. Such acknowledgements constitute the fundamental basis for the emergence of authority.

## CONCLUSIONS

The computer mystique is an orientation to computers that is founded in false beliefs about the capability of the computer or a particular computer system. The data from the Computer Literacy Field Study and the Computer Literacy Laboratory Experiment together substantiate the feasibility of measuring the subtle beliefs and feelings associated with the computer mystique. Our indicators of the mystique are diffuse and not specific to particular computer systems. Subsequent research should expand this assessment of the computer mystique, particularly with respect to specific information systems.

The test results from over 1,000 Minnesota high school students support our original hypothesis that the computer mystique is more than illiteracy and ignorance. The data clearly show that the computer mystique is linked to important values and attitudes in domains other than computing.

The laboratory experiment designed to study the social impact of Computer Based Education (CBE) disclosed that a mere 15-30 minutes of a CBE learning activity can magnify the mythology central to the computer mystique. While students obviously learn a great deal from CBE, we found an instance where they unintendedly learned misconceptions about the medium that delivered the instruction.

These findings should not be construed as a universal indictment of the use of computers in education. The Computer Literacy Field Study found that the computer mystique among students declined during the period of the computer classes they were taking. Consequently, the typical mode of computer utilization in education appears to reduce the computer mystique.

The data we have reported here all seems to suggest that computer literacy (knowledge) is the best insultation against the computer mystique. Within every CBE system there is an implied control system which may indirectly foster the computer mystique. Designers of CBE systems would do well to be more cognizant of the implicit social assumptions embedded within these systems.

This empirical effort has led us into a conceptual arena that we did not initially foresee. The key insight which has emerged from the data is the intimacy of the connection between an exaggerated sense of the computer and an orientation toward authority. Several facets of the authority orientation deserve further attention. One is the ability to differentiate legitimate from illegitimate authorities. Another is acceptance and trust of authority. These facets of authority appear to be most closely related to the attribution of power and blame to man and machine.

## REFERENCES

Anderson, Ronald E.
1977 "Computer stereotyping in popular humor" Futurics, 2, 1 (summer), 2-6.

Anderson, Ronald E.; Hansen, Thomas; Johnson, David; Klassen, Daniel
1979a "Instructional computing: acceptance and rejection by secondary teachers," Sociology of Work Occupations, 6, 2 (May 1979).

Anderson, Ronald E.; Hansen, Thomas; Johnson, David; Klassen, Daniel
1979b The Minnesota Computer Literacy Tests, Minnesota Educational Computing Consortium, St. Paul, MN.

Bailey, Daniel E.
1979 "Ingredients for excellence in computer based education systems," pp 2-6 in Proceedings of the National Educational Computing Conference, University of Iowa, Iowa City, IA.

Dunn, Christopher S. and Zimmerman, Sherwood E.
1979 "Who's on first: changes wrought by computerized decision-making in criminal justice," Center for Studies of Crime and Delinquency, Rockville, MD.

Durkheim, Emile
1912 The Elementary Forms of Religious Life, London: Allen and Unwin; New York: Macmillan.

Easton, David and Dennis, Jack
1969 Children in the Political System, New York: McGraw Hill Book Co.

Eliade, Mircea
1957 The Sacred and the Profane, New York: Harcourt.

Ellul, Jacques
1964 The Technological Society, New York: Random House.

Jung, Carl G.
1953 Psychological Reflections: An Anthology of Writings, New York: Harper.

Malinowski, Bronislaw
1925 Magic, Science and Religion, Glencoe, IL: Free Press.

Marshall, Clifford and McGuire, Thomas
1971 "The computer as social pressure to produce conformity in a simple perceptual task," AV Communication Review, 19, 1 (spring), 19-29.

Mowshowitz, Abbe
1976 The Conquest of Will: Information Processing in Human Affairs, Reading, MA: Addison-Wesley Publshing Co.

Nowicki, S., Jr. and Strickland, B. R.
1973 "A lows of control scale for children," Journal of Counseling and Clinical Psychology, 40, pp 148-154.

Raphael, Bertram
1976 The Thinking Computer: Mind Inside Matter, San Francisco, CA: W. H. Freeman and Co.

Schneider, Ben Ross, Jr.
1974 Travels in Computerland, Reading, MA: Addison Wesley.

Turkle, Sherry
1979 "The computer as a Rorschach blot," Department of Sociology, MIT, Cambridge, MA.

Turner, Victor W.
1968 "Myth and symbol," pp 576-581 in International Encyclopedia of the Social Sciences, Second Edition.

Weizenbaum, Joseph
1976 Computer Power and Human Reason, San Francisco, CA: W. H. Freeman and Co.

APPENDIX C

"COMPUTER LITERACY - WHAT IS IT?"

REMOVED DUE TO COPYRIGHT RESTRICTIONS

APPENDIX D

"A SURVEY ABOUT EDUCATION AND COMPUTING"

# A SURVEY ABOUT EDUCATION AND COMPUTERS

Page 1. *To be completed by all teachers.*

1. District Name and Number ____________________

2. School Name ____________________

3. Grade levels that you teach. Circle all that apply.

   6 7 8 9 10 11 12

4. Areas in which you are teaching. Check all that apply.

   ____ mathematics
   ____ science
   ____ computer science
   ____ business education
   ____ data processing
   ____ other (please indicate) ____________
   ____ other (please indicate) ____________

5. Have you received training (through college courses, workshops, self-learning) about computers or computer use in education?

   ____ yes
   ____ no

   If yes, check each area that applies:

   ____ computer use in your discipline
   ____ business data processing
   ____ computer programming
   ____ survey of computers in education
   ____ computer science
   ____ other (please indicate) ____________

6. In your school, how many computer keyboard terminals or computers are available for student use? Circle the one that applies.

   0 1 2 3 4 5 6 7 8 9 10+ don't know

7. Is a computer terminal available for use with your classes?

   ____ yes, anytime I need it
   ____ yes, some of the time
   ____ no
   ____ don't know

8. Does your school have a student computer club?

   ____ yes
   ____ no
   ____ don't know

9. Number of years (including current school year) you have been teaching: ____________

10. Number of years (including current school year) you have been using or teaching about the computer in your classroom. Circle the one that applies.

    0 1 2 3 4 5 6 7 8 9 10 11 12 13+

11. Your sex: ____ female
    ____ male

* * * * * * * * * * * * * * * * * * * * * * * * *

★ *Please read each statement and circle the number on the scale that best represents your opinion.* ★

| | STRONGLY DISAGREE | DISAGREE | UNDECIDED | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| 12. Every secondary school student should have some minimal understanding of computers. | 1 | 2 | 3 | 4 | 5 |
| 13. Every secondary school student should be able to write a simple program. | 1 | 2 | 3 | 4 | 5 |
| 14. Every secondary school student should learn about the role that computers play in our society. | 1 | 2 | 3 | 4 | 5 |
| 15. My training has adequately equiped me to make decisions about using computers in my teaching. | 1 | 2 | 3 | 4 | 5 |
| 16. The effort necessary to integrate computers into my teaching is an inefficient use of my time. | 1 | 2 | 3 | 4 | 5 |
| 17. Computers can be a useful instructional aid in many subject areas other than mathematics. | 1 | 2 | 3 | 4 | 5 |
| 18. Computers provide more disadvantages than advantages in education. | 1 | 2 | 3 | 4 | 5 |

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

The second page of this questionnaire is to be filled out only by those teachers who use the computer or teach about computer-related topics. If you do not teach about or with computers, please fold the questionnaire so that the MECC address and postage permit are visible, staple it, and mail it.

Thank you for your help.

1. Below is a list of different ways that teachers use or teach about computers. In the spaces provided (columns 1-6), please list the courses you teach that involve computers and check all categories that apply. The example at the left illustrates how a teacher who is teaching two sections of General Math, grade 9, where the computer is used for calculation, and one section of Social Problems, grades 11-12, which includes a consideration of computers in society, would complete this form.

| | EXAMPLE a | EXAMPLE b | YOUR COURSES 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| GRADE LEVEL(S) | 9 | 11-12 | | | | | | |
| NUMBER OF SECTIONS | 2 | 1 | | | | | | |
| COURSE TITLE | General Math | Social Problems | | | | | | |
| **TYPE OF ACTIVITY** | | | | | | | | |
| as a calculator | X | | | | | | | |
| run simulations | | X | | | | | | |
| student instructional games | | | | | | | | |
| student leisure time activity | | | | | | | | |
| student problem solving | | | | | | | | |
| drill students in math, spelling, etc. | | | | | | | | |
| as a tutor (teaching specific content) | | | | | | | | |
| demonstrate concepts | | | | | | | | |
| score teacher-developed tests | | | | | | | | |
| instructional management | | | | | | | | |
| materials generation (test or worksheet) | | | | | | | | |
| information retrieval (e.g., MOIS, GIS) | | | | | | | | |
| student analysis of data | | | | | | | | |
| teach electronics | | | | | | | | |
| teach programming | | | | | | | | |
| teach computer terminal operation | | | | | | | | |
| teach data processing procedures | | | | | | | | |
| teach Hardware and Software concepts | | | | | | | | |
| teach history of computers | | | | | | | | |
| teach how computers are applied | | | | | | | | |
| teach about computer careers | | X | | | | | | |
| teach about role and impact of computers in society | | X | | | | | | |

2. If your students use a computer, which mode of input do they use? (Check all that apply.)

___ keyboard terminals ___ punch cards ___ mark sense cards ___ paper tape ___ magnetic tape

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

To help us identify teachers who are using different approaches, we need your name:

Your Name (please print) ________________________________

We need to identify teachers in order to select a sample to participate in the next phase of the study. Teachers who agree to participate further will be asked to provide us with more information. In addition, they will be asked to use computer literacy tests developed to measure changes in their students' attitudes, knowledge, and skills. In this way, we can gain more insight into the effects of various approaches of introducing computers into the curriculum, and then develop appropriate materials for teachers.

Thank you for taking your valuable time to complete this questionnaire. Now here comes the easy part--just fold, staple, and drop it in the mail.

Thanks again.

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 171, ST. PAUL, MINN.

State of Minnesota
Central Mail
MECC
G19-Department of Transportation Building
St. Paul, Minnesota 55155

APPENDIX E

COMPUTER LITERACY QUESTIONNAIRE

# COMPUTER LITERACY QUESTIONNAIRE

MINNESOTA EDUCATIONAL COMPUTING CONSORTIUM

2520 Broadway Drive

St. Paul, Mn. 55113

Supported by the National Science Foundation. Grant No. SED77-18658

Your Name (please print)________________________________

Dear Student:

We would appreciate your help by having you answer the questions in this booklet. There are two parts: the first part asks for your opinions and attitudes and the second part is a test of your knowledge about computers. Keep in mind that in the first part (the attitude questions) there are no right answers or wrong answers; just select the answer that best expresses how you feel. In the second part (the computer knowledge test) there may be items you have not yet learned. Just answer as many as you can. Keep in mind that the right answer is the best choice for each question.

## PART 1

DIRECTIONS: Indicate how much you AGREE or DISAGREE with each of the following statements by circling the appropriate letter. Circle "a" if you STRONGLY DISAGREE with the statement. Circle "b" if you DISAGREE with the statement a little. Circle "c" if you are UNDECIDED about whether you agree or disagree with the statement. Circle "d" if you AGREE with the statement a little. Circle "e" if you STRONGLY AGREE with the statement.

As an example, if you AGREE a little that computers are noisy, then circle "d" as shown below:

Computers are noisy . . . a b c d e

Or, if you are UNDECIDED about whether computers are noisy, circle "c" as shown below:

Computers are noisy . . . a b c d e

If you have any questions, ask your teacher.

| | STRONGLY DISAGREE | DISAGREE | UNDECIDED | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| | a | b | c | d | e |
| 1. I would like to learn more about computers.. | a | b | c | d | e |
| 2. Working with a computer would probably make me feel uneasy or tense.................. | a | b | c | d | e |
| 3. I feel helpless around a computer........ | a | b | c | d | e |
| 4. Computers sometimes scare me.............. | a | b | c | d | e |
| 5. I would very much like to have my own computer.................................. | a | b | c | d | e |
| 6. I would like the idea of taking computer courses.................................. | a | b | c | d | e |
| 7. I enjoy using computers in my classes...... | a | b | c | d | e |
| 8. Walking through a room filled with computers would make me feel uneasy................. | a | b | c | d | e |

| | STRONGLY DISAGREE | DISAGREE | UNDECIDED | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| | a | b | c | d | e |
| 9. I feel uneasy when I am with people who are talking about computers.................... | a | b | c | d | e |
| 10. I enjoy working with computers................ | a | b | c | d | e |
| 11. I feel confident about my ability to use computers.................................. | a | b | c | d | e |
| 12. It is my guess that I am <u>not</u> the kind of person who works well with computers.......... | a | b | c | d | e |
| 13. On the whole, I can cope with computers in my daily living.............................. | a | b | c | d | e |
| 14. I am able to work with computers as well as most others my age......................... | a | b | c | d | e |
| 15. Computers are gaining too much control over people's lives............................. | a | b | c | d | e |
| 16. In general, females can do just as well as males in computer careers..................... | a | b | c | d | e |
| 17. More females than males have the ability to become computer specialists................ | a | b | c | d | e |
| 18. Using computers is more for males than for females.................................. | a | b | c | d | e |
| 19. Studying about computers is just as important for females as for males.................... | a | b | c | d | e |
| 20. Men make better scientists and engineers than women do.................................. | a | b | c | d | e |
| 21. Falsifying information in computers is a serious crime.................................. | a | b | c | d | e |
| 22. Access to personal information in computer files is a serious problem.................. | a | b | c | d | e |
| 23. Organizations should <u>not</u> be allowed to create secret computer files containing detailed information regarding people's personal lives.................................. | a | b | c | d | e |
| 24. Because of computerized information files, too many people have information about other people.................................. | a | b | c | d | e |

| | STRONGLY DISAGREE | DISAGREE | UNDECIDED | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| | a | b | c | d | e |
| 25. To protect people's privacy it is necessary to have laws regarding computer files that contain personal data.......................... | a | b | c | d | e |
| 26. Every secondary school student should have some minimal understanding of computers.......... | a | b | c | d | e |
| 27. Every secondary school student should be able to write a simple program.......................... | a | b | c | d | e |
| 28. Every secondary school student should learn about the role that computers play in our society.......................................... | a | b | c | d | e |
| 29. Computers can be a useful instructional aid in many subject areas other than mathematics..... | a | b | c | d | e |
| 30. Computers provide more disadvantages than advantages in education.......................... | a | b | c | d | e |

DIRECTIONS: Indicate whether you think each of the following values is UNIMPORTANT, IMPORTANT, or EXTREMELY IMPORTANT by circling the appropriate letter. Circle "a" if you think the value is UNIMPORTANT. Circle "b" if you think the value is IMPORTANT. Circle "c" if you think it is EXTREMELY IMPORTANT.

As an example, if you think saving money is EXTREMELY IMPORTANT, circle "c" as shown below:

Saving money a b c

| | UNIMPORTANT | IMPORTANT | EXTREMELY IMPORTANT |
|---|---|---|---|
| | a | b | c |
| 31. Freedom ............................................ | a | b | c |
| 32. World Peace ........................................ | a | b | c |
| 33. Economic Growth .................................... | a | b | c |

| | UNIMPORTANT | IMPORTANT | EXTREMELY IMPORTANT |
|---|---|---|---|
| | a | b | c |
| 34. Scientific Knowledge | a | b | c |
| 35. Privacy | a | b | c |
| 36. Technological Advancement | a | b | c |
| 37. Computerization | a | b | c |
| 38. Efficiency | a | b | c |
| 39. Love and Friendship | a | b | c |
| 40. Self Respect | a | b | c |

DIRECTIONS: Below are some adjectives that can be used to describe computers. For each adjective circle the alternative which best expresses how you feel about computers. If you aren't sure how you feel, circle "undecided." As an example, if you feel that computers are very big, then circle as shown here:

a. not big  b. big  c. very big  d. undecided

If you feel that computers are not big, then circle as shown here:

a. not big  b. big  c. very big  d. undecided

Circle one alternative for each of the eight adjectives.

COMPUTERS ARE:

41. a. not personal  b. personal  c. very personal  d. undecided
42. a. not frustrating  b. frustrating  c. very frustrating  d. undecided
43. a. not good  b. good  c. very good  d. undecided
44. a. not humanizing  b. humanizing  c. very humanizing  d. undecided
45. a. not challenging  b. challenging  c. very challenging  d. undecided
46. a. not bad  b. bad  c. very bad  d. undecided
47. a. not impersonal  b. impersonal  c. very impersonal  d. undecided
48. a. not dehumanizing  b. dehumanizing  c. very dehumanizing  d. undecided

PART II

DIRECTIONS: For each of the following questions, circle the letter beside the best answer. If you do not know the answer to a question, do not leave the item blank; circle the letter beside "I don't know." Use the "I don't know" response as little as possible. Use the "I don't know" response only when you don't even have a guess about the best answer. Do NOT leave any item blank that you attempt; either circle the letter beside an answer or "I don't know."

1. Police sometimes use computers to help identify stolen cars.

   a. true
   b. false
   c. I don't know

2. Most hospitals give injections by computer.

   a. true
   b. false
   c. I don't know

3. Computers cannot be used to assist in teaching English grammar.

   a. true
   b. false
   c. I don't know

4. Computers are not really used very much yet except by scientists.

   a. true
   b. false
   c. I don't know

5. Government officials use computers to store and retrieve large amounts of information about citizens.

   a. true
   b. false
   c. I don't know

6. People often use computers to store large amounts of information they wish to use over and over again.

   a. true
   b. false
   c. I don't know

7. Computers help people make decisions by providing correct answers to any question.

   a. true
   b. false
   c. I don't know

8. Computers help people make decisions by telling them if their problem is important.

a. true
b. false
c. I don't know

9. Computers have been used to make more information and products available to the consumer.

a. true
b. false
c. I don't know

10. Computers are used to commit crimes, especially stealing money and stealing or falsifying information.

a. true
b. false
c. I don't know

11. Identification numbers and passwords are a primary means for restricting undesired access to computer files.

a. true
b. false
c. I don't know

12. Use of computers in education always results in less personal treatment of students.

a. true
b. false
c. I don't know

13. Privacy is an issue with files containing personal information about people.

a. true
b. false
c. I don't know

14. The increased use of computers in our society both eliminates and creates jobs.

a. true
b. false
c. I don't know

15. Almost all people in our society are affected in some way by computers.

a. true
b. false
c. I don't know

16. In order to use a computer you would have to be in the same building as the computer.

a. true
b. false
c. I don't know

17. Computers are able to think in every way just like people.

a. true
b. false
c. I don't know

18. Using computers can free one to do more creative tasks, but this may lead to more dependence upon machines.

a. true
b. false
c. I don't know

19. In order to use any computer you would have to use a telephone.

a. true
b. false
c. I don't know

20. In order to use a computer a person must know how to program.

a. true
b. false
c. I don't know

21. Computers are not good for tasks that require:

a. speed
b. accuracy
c. intuition
d. something to be done over and over again
e. I don't know

22. If your charge account bill has an error, it was probably caused by:

a. breakdown of the computer
b. mistakes made by people
c. poor design of the computer
d. general weaknesses of machines
e. I don't know

23. The main duty of a computer programmer is to:

a. operate a computer
b. prepare instructions for a computer
c. schedule jobs for a computer
d. design computers
e. I don't know

24. The computer related job closest to that of a typist is:

a. computer operator
b. keypunch operator
c. systems analyst
d. computer programmer
e. I don't know

25. Which of the following persons is the most likely to be associated with the design of computers?

a. keypunch operator
b. computer operator
c. computer programmer
d. computer scientist
e. I don't know

26. A basic use of computers in libraries involves:

a. information storage and retrieval
b. simulation and modelling
c. process control
d. computation
e. I don't know

27. A basic use for computers in the design of airplanes is:

a. simulation and modelling
b. process control
c. making reservations
d. keeping inventory
e. I don't know

28. The most questionable use of large computer files is:

a. government planning
b. research
c. checking on people
d. administration of social programs
e. I don't know

29. Which of the following is a limiting consideration for using computers?

a. cost
b. software availability
c. storage capacity
d. all of the above
e. I don't know

30. Which is not a characteristic of most information systems?

a. a large volume of information is stored and used
b. the information is organized
c. the basic purpose is to provide reports and summaries of the data
d. they contain only alphabetic data
e. I don't know

31. The decade of first extensive manufacturing of computers was:

a. 1860's
b. 1890's
c. 1920's
d. 1950's
e. I don't know

32. Computer software is a term describing:

a. computer programs
b. electronic components encased in soft plastic or rubber
c. people who work with computers
d. mechanical and electronic parts of a computer system
e. I don't know

33. In addition to input and output equipment, computers contain:

a. terminals, paper, transistors
b. memory units, control units, arithmetic units
c. printers and typewriters
d. telephones, keyboards, television screens
e. I don't know

34. A computer <u>system</u> is best described as:

a. processing
b. programming, input, and output
c. input and output
d. input, processing, and output
e. I don't know

35. The physical parts of a computer are referred to as:

a. programs
b. hardware
c. software
d. manuals
e. I don't know

36. When in operation, a computer:

a. follows a set of instructions written by people
b. thinks just like a person
c. recalls answers from memory
d. translates data from digital to analog code
e. I don't know

37. Computers <u>cannot</u> run without:

a. blinking lights
b. keyboards
c. instructions
d. all of the above
e. I don't know

38. In order to program a computer, a person:

a. can use any English language words
b. can use any English or foreign language words
c. must use programming language numbers, not words
d. must use the words from a programming language
e. I don't know

39. At any given moment, a computer's memory unit can store:

a. programs
b. data
c. answers
d. all of the above
e. I don't know

40. Data processing is best described as:

a. the collection of data
b. producing reports
c. manipulating data according to instructions
d. using punched cards in a keypunch machine
e. I don't know

41. A computer program is a:

a. course on computers
b. set of instructions to control the computer
c. computer generated presentation
d. piece of computer hardware
e. I don't know

42. Computer processing of data may involve:

a. searching
b. summarizing
c. deleting
d. all of the above
e. I don't know

43. The computer must have two types of information to solve a problem:

a. the problem and the answer
b. the name of the program and user number
c. the data and the instructions
d. the name of the program and your name
e. I don't know

44. A newspaper publisher has the following information about subscribers stored in the computer. They are name, address and renewal date. How would you arrange the information to be most useful to the delivery person?

a. ordered listing by address
b. ordered listing by renewal dates
c. alphabetical listing of streets
d. ordered listing by zip code
e. I don't know

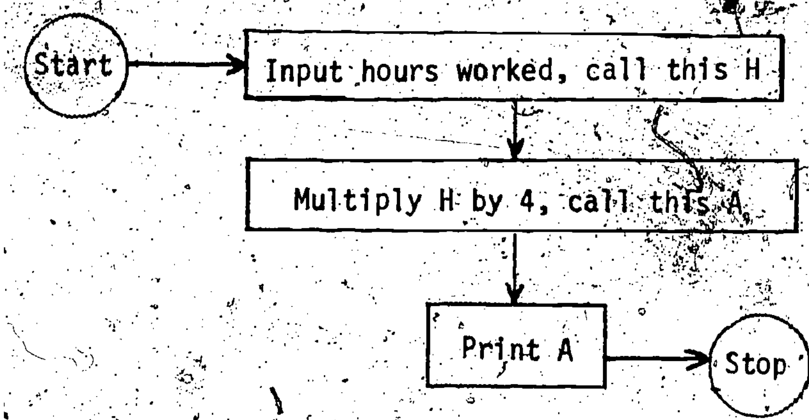
45. Choose the correct output for the procedure described below:

1. List the three names Brown, Anderson and Crane in alphabetical order
2. Remove the last name from the list
3. If only one name is left, stop. Otherwise, go on to step 4
4. List the remaining names in reverse order
5. Go back to step 2

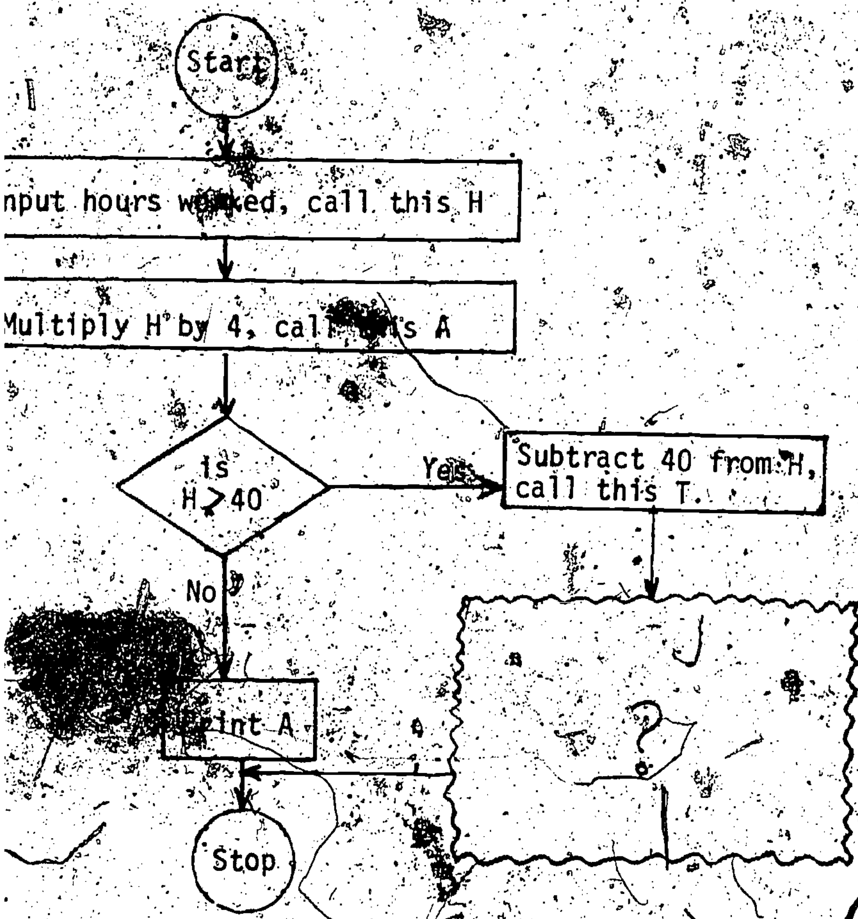
<u>Output</u>

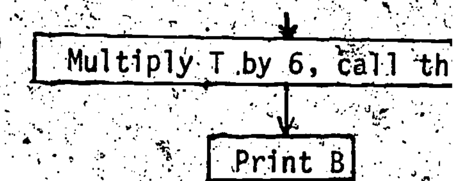
a. Anderson, Brown, Crane
b. Brown
c. Anderson, Brown
d. Anderson
e. I don't know

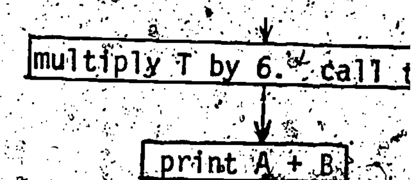
46. An algorithm (flowchart) to determine the weekly wages of employees in a bakery is shown below. Employees are paid $4 per hour up to 40 hours per week.

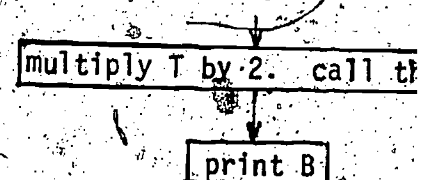


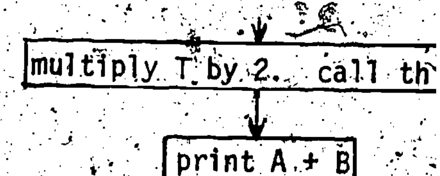

Employees are also paid "time-and-a-half" ($6 per hour) for overtime (hours worked over 40). How would you extend the flowchart below to include overtime pay. Select answer a, b, c, d, or e.




a.)



b.)



c.)



d.)



e.) I don't know.

DIRECTIONS: If you have never written a computer program, STOP: do NOT answer items 1 - 3 below. Answer items 1 - 3 only if you have written a computer program before.

1. Choose the correct output for the computer program shown below:

```
1    LET A = 3
2    LET B = 4
3    LET C = A
4    LET B = C
5    LET A = B
6    PRINT A,B
7    END
```

Output

a. 3 4
b. 4 3
c. 3 3
d. 4 4
e. I don't know

2. When run on a computer, the following program will:

```
1    INPUT A, B, C, D, E
2    LET S = A+B+C+D+E
3    LET M = S/5
4    PRINT S,M
5    END
```

a. Calculate the sum of five input values
b. Calculate the average of five input values
c. Print the sum and average of five input values
d. all of the above
e. I don't know

3. This program instructs the computer to count by two.

```
10  LET M = 0
20  LET M = M + 2
30  PRINT M
40  IF M<100 THEN 20
50  END
```

Which change will produce a program which can be used to count by A? (For example, A=3, 5, or 8.)

a. 5 READ A
   7 DATA 3,5,8

b. 5 LET M = A
   30 PRINT A

c. 5 INPUT A
   20 LET M = M + A

d. 5 LET X = A
   20 LET M = X + A

e. I don't know

APPENDIX F

"THE MINNESOTA COMPUTER LITERACY TESTS:
A TECHNICAL REPORT"

MISSING FROM DOCUMENT PRIOR TO ITS BEING SHIPPED TO EDRS FOR FILMING.

APPENDIX G

"COMPUTER LITERACY COURSES"

REMOVED DUE TO COPYRIGHT RESTRICTIONS

APPENDIX H

COURSE/UNIT ACTIVITY LOG AND

PARTICIPANT QUESTIONNAIRE

COURSE/UNIT ACTIVITY LOG

Week of ______________ to ______________

Name ______________________________

Goals and Objectives

Topics Covered

Student Activities

Unusual Features

Materials Used

Use of the Computer

## COMPUTER LITERACY PROJECT -- PARTICIPANT QUESTIONNAIRE

Your name: ______________________________

Name of the course being used in the study: ______________________________

Check the appropriate box for each statement or question (in some cases you are asked to Enter a Number).

### Part I - Course Background

1. Enrollment.

   - [ ] The course is required for all students.
   - [ ] The course is required for some students.
   - [ ] The course is elective for all students.

2. How often the course meets (class periods per week).

   - [ ] 3 times per week
   - [ ] 5 times per week
   - [ ] Other [ ] (Please Enter a Number as well as a check mark.)

3. How long is each class period.

   - [ ] Enter a number

4. How many class sessions were held between the study pre- and post-test (do not include the pre- and post-test sessions).

   - [ ] Enter a Number

5. Indicate how many class sessions (between the study pre- and post-test) included computer topics or actual computer use.

   - [ ] Enter a Number

6. Estimate how many hours per week the typical student in your class actually spent using the computer (using a terminal or direct access to the machine).

   - [ ] In class - Enter a Number
   - [ ] Outside of class - Enter a Number

7. How many terminals and computers are in your school building?

   - [ ] Enter a Number

8. Is there a specially designated computer room or computer laboratory in your school building?

   [ ] Yes

   [ ] No

9. Estimate the average number of hours per day that your students have open access to a terminal or computer in your school building.

   [ ] Enter a Number

10. Do you use or teach about computers in other classes that you teach?

   [ ] Yes

   [ ] No

11. Which of the following BASIC programming statements do you expect your students to be able to use (if you use other languages, please attach a list of the statements from that language). If your answer to this is "none", please leave this blank and go on to question 11.

| | |
|---|---|
| [ ] PRINT | [ ] RETURN |
| [ ] END | [ ] REM |
| [ ] LET | Others (please check and list) |
| [ ] GO TO | [ ] ______ |
| [ ] IF... THEN | [ ] ______ |
| [ ] INPUT | [ ] ______ |
| [ ] READ, DATA | [ ] ______ |
| [ ] FOR, NEXT | [ ] ______ |
| [ ] DIM | [ ] ______ |
| [ ] GO SUB | [ ] ______ |

## Part II - Objectives

The following list reflects a number of possible objectives in the area of computer literacy. Please check the appropriate column entry in terms of whether or not this was an objective (major or minor) for the course.

### Computer Literacy Objectives - Cognitive

| Hardware (H)[a] | | Not an Objective | Minor Objective | Major Objective |
|---|---|---|---|---|
| H.1.1 | Identify the five major components of a computer: input equipment, memory unit, control unit, arithmetic unit, output equipment. | | | |
| H.1.2 | Identify the basic operation of a computer system. Input of data or information - Processing of data or information - Output of data or information. | | | |
| H.1.3 | Distinguish between hardware and software. | | | |
| H.1.4 | Identify how a person can access a computer; e.g., | | | |
| | 1. via a keyboard terminal | | | |
| | a. at site of computer | | | |
| | b. at any distance via telephone lines | | | |
| | 2. via punched or marked cards | | | |
| | 3. via other magnetic media (tape, diskette) | | | |
| H.1.5 | Recognize the rapid growth of computer hardware since the 1940's. | | | |
| H.2.1 | Determine that the basic components function as an interconnected system under the control of a stored program developed by a person. | | | |
| H.2.2 | Compare computer processing and storage capabilities to the human brain listing some general similarities and differences. | | | |

**Programming and Algorithms (P)**

NOTE: The student should be able to accomplish objectives 1.2 - 2.8 when the algorithm is expressed as a set of English language instructions and in the form of a computer program.

| | | Not an Objective | Minor Objective | Major Objective |
|---|---|---|---|---|
| P.1. | Recognize the definition of "algorithm." | | | |
| P.1.2 | Follow and give the correct output for a simple algorithm. | | | |
| P.1.3 | Given a simple algorithm explain what it accomplishes (i.e., interpret & generalize). | | | |
| P.2.1 | Modify a simple algorithm to accomplish a new but related task. | | | |
| P.2.3 | Correct errors in an improperly functioning algorithm. | | | |
| P.2.4 | Develop an algorithm for solving a specific problem. | | | |
| P.2.5 | Develop an algorithm which can be used to solve a set of similar problems. | | | |

a. Note that the coding is H - Hardware, P - Programming and Algorithms, S - Software and Data Processing, A - Applications, and I - Impact. Also, for each statement the first digit after the letter refers to a cognitive level - 1 indicating a low level, generally a skill or knowledge of facts and 2 standing for a higher level of understanding, requiring some analysis and/or synthesis. The final digit is merely a count of items within each level. While no priority is intended with the final digit, there has been an attempt to place the ideas in some of logical sequence.

| | | Not an Objective | Minor Objective | Major Objective |
|---|---|---|---|---|
| **Software and Data Processing (S)** | | | | |
| S.1.1 | Identify the fact that we communicate with computers through a binary code. | | | |
| S.1.2 | Identify the need for data to be organized if it is to be useful. | | | |
| S.1.3 | Identify the fact that information is data which has been given meaning. | | | |
| S.1.4 | Identify the fact that data is a coded mechanism for communication. | | | |
| S.1.5 | Identify the fact that communication is the transmission of information via coded messages. | | | |
| S.1.6 | Identify the fact that data processing involves the transformation of data by means of a set of pre-defined rules. | | | |
| S.1.7 | Recognize that a computer needs instructions to operate. | | | |
| S.1.8 | Recognize that a computer gets instructions from a program written in a programming language. | | | |
| S.1.9 | Recognize that a computer is capable of storing a program and data. | | | |
| S.1.10 | Recognize that computers process data by searching, sorting, deleting, updating, summarizing, moving, etc. | | | |
| S.2.1 | Select an appropriate attribute for ordering of data for a particular task. | | | |
| S.2.2 | Design an elementary data structure for a given application (that is, provide order for the data). | | | |
| S.2.3 | Design an elementary coding system for a given application. | | | |
| **Applications (A)** | | | | |
| A.1.1 | Recognize specific uses of computers in some of the following fields:<br>a. medicine<br>b. law enforcement<br>c. education<br>d. engineering<br>e. business<br>f. transportation<br>g. military defense systems<br>h. weather prediction<br>i. recreation<br>j. government<br>k. the library<br>l. creative arts | | | |
| A.1.2 | Identify the fact that there are many programming languages suitable for a particular application for business or science. | | | |
| A.2.1 | Recognize that the following activities are among the major types of applications of the computer:<br>a. information storage and retrieval<br>b. simulation and modelling<br>c. process control - decision-making<br>d. computation<br>e. data processing | | | |

| | | Not an Objective | Minor Objective | Major Objective |
|---|---|---|---|---|
| A.2.2 | Recognize that computers are generally good at information processing tasks that benefit from: a. speed b. accuracy c. repetitiveness | | | |
| A.2.3 | Recognize that some limiting considerations for using computers are: a. cost b. software availability c. storage capacity | | | |
| A.2.4 | Recognize the basic features of a computerized information system. | | | |
| A.2.5 | Determine how computers can assist the consumer. | | | |
| A.2.6 | Determine how computers can assist in a decision-making process. | | | |
| A.2.7 | Assess the feasibility of potential application. | | | |
| A.2.8 | Develop a new application. | | | |

Impact (I)

| | | Not an Objective | Minor Objective | Major Objective |
|---|---|---|---|---|
| I.1.1 | Distinguish among the following careers: a. keypuncher/keyoperator b. computer operator c. computer programmer d. systems analyst e. computer scientist | | | |
| I.1.2 | Recognize that computers are used to commit a wide variety of serious crimes but especially stealing money and stealing information. | | | |
| I.1.3 | Recognize that identification codes (numbers) and passwords are a primary means for restricting use of computer systems, of computer programs, and of data files. | | | |
| I.1.4 | Recognize that procedures for detecting computer-based crimes are not well developed. | | | |
| I.1.5 | Identify some advantages or disadvantages of a data base containing personal information on a large number of people (e.g., the list might include value for research and potential for privacy invasion.) | | | |
| I.1.6 | Recognize several regulatory procedures; e.g., privilege to review one's own file and restrictions on use of universal personal identifiers, which help to insure the integrity of personal data files. | | | |
| I.1.7 | Recognize that most "privacy problems" are characteristic of large information files whether or not they are computerized. | | | |
| I.1.8 | Recognize that computerization both increases and decreases employment. | | | |
| I.1.9 | Recognize that computerization both personalizes and impersonalizes procedures in fields such as education. | | | |

| | | Not an Objective | Minor Objective | Major Objective |
|---|---|---|---|---|
| I.1.10 | Recognize that computerization can lead to both greater independence and dependence upon one's tools. | | | |
| I.1.11 | Recognize that while computers do not have the mental capacity that humans do, through techniques such as artificial intelligence, computers have been able to modify their own instruction set and do many of the information processing tasks that humans do. | | | |
| I.1.12 | Recognize that alleged "computer mistakes" are usually mistakes made by people. | | | |
| I.2.1 | Plan a strategy for tracing and correcting a computer related error such as a billing error. | | | |
| I.2.2 | Explain how computers make public surveillance more feasible. | | | |
| I.2.3 | Recognize that even though a person does not go near a computer, he or she is affected indirectly because the society is different in many sectors as a consequence of computerization. | | | |
| I.2.4 | Explain how computers can be used to impact the distribution and use of economic and political power. | | | |

## Computer Literacy Objectives - Affective

Attitude, Values, and Motivation (V)[b]

| | | | | |
|---|---|---|---|---|
| V.1 | Does not feel fear, anxiety, or intimidation from computer experiences. | | | |
| V.2 | Feels confident about his/her ability to use and control computers. | | | |
| V.3 | Values efficient information processing provided that it does not neglect accuracy, the protection of individual rights, and social needs. | | | |
| V.4 | Values computerization of routine tasks so long as it frees people to engage in other activities and is not done as an end in itself. | | | |
| V.5 | Values increased communication and availability of information made possible through computer use provided that it does not violate personal rights to privacy and accuracy of personal data. | | | |
| V.6 | Values economic benefits of computerization for a society. | | | |
| V.7 | Enjoys and desires work or play with computers, especially computer assisted learning. | | | |
| V.8 | Describes past experiences with computers with positive-affect words like fun, exciting, challenging, etc. | | | |
| V.9 | Given an opportunity, spends some free time using a computer. | | | |

[b] The coding scheme, V.1 - V.9, is merely for recording purposes and is not intended to convey any priorities or hierarchy.

## Part III - Use of Computers

Below is a list of different ways that teachers use or teach about computers. For each activity estimate the total hours of class time (between the study pre- and post-test) for which this activity was included or had some role in the educational process.

| Activity | Hours of Class Time |
|---|---|
| As a calculator | ______ |
| Run simulations | ______ |
| Student instructional games | ______ |
| Student leisure time activity | ______ |
| Student problem solving | ______ |
| Drill students in math, spelling, etc. | ______ |
| As a tutor (teaching specific content) | ______ |
| Demonstrate concepts | ______ |
| Score teacher-developed tests | ______ |
| Instructional management | ______ |
| Materials generation (test or worksheet) | ______ |
| Information retrieval (e.g., MOIS, GIS) | ______ |
| Student analysis of data | ______ |
| Teach electronics | ______ |
| Teach programming | ______ |
| Teach computer terminal operation | ______ |
| Teach data processing procedures | ______ |
| Teach hardware and software concepts | ______ |
| Teach history of computers | ______ |
| Teach how computers are applied | ______ |
| Teach about computer careers | ______ |
| Teach about role and impact of computers in society | ______ |

Part IV - Student Achievement/Ability Data

On the following page is a list of students in your class who participated in the Computer Literacy Project. We would like you to:

(1) Indicate the grade the student received in the class, and

(2) Estimate whether the student is above average, average or below average in overall academic ability compared to other students in your school.

We have included the student test numbers that we use to match pre- and post-tests for individual students. We have also included the names of the students. After you have completed the form, please cut off the student names. As noted in previous correspondence, students will not be identified as individuals.

Teacher: ______________________

Class: ______________________

Please cut along dotted line

| | Overall Academic Ability | | | | |
|---|---|---|---|---|---|
| Grade Given | Below Average | Average | Above Average | Student # | Student Name |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Part V - Student Computer Literacy Questionnaire

Questions 11 - 15 are your ratings of the study Computer Literacy Questionnaire as to its difficulty for your students.

12. Level of reading

- [ ] difficult
- [ ] about right
- [ ] easy

13. Length

- [ ] too long
- [ ] about right
- [ ] too short

14. Instructions

- [ ] confusing
- [ ] understandable

15. Content

- [ ] difficult
- [ ] about right
- [ ] easy

16. Quality of the questions

- [ ] poorly stated
- [ ] satisfactory
- [ ] excellent

Part VI - Other Comments - Please use this space to give us any reactions you have regarding any topic related to this study. (Use back side of paper if more space is needed.)